Scientific Papers and Letters

BY

A. H. SMEE, M.R.C.S., F.C.S., F.S.S.


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Author's Compliments.

SCIENTIFIC PAPERS AND LETTERS

BY

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PREFACE.

I HAVE been so frequently asked by my friends for copies of the scientific papers and letters written by me at various times, that I have decided to produce them in their present form. This is my apology for their re-publication.

THE AUTHOR.

The Grange,

Carshalton.

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ON THE

ARTIFICIAL PRODUCTION

OF

FIBRIN FROM ALBUMEN.

BY

ALFRED HUTCHISON SMEE, JUNIOR,

Student of St. Bartholomew's Hospital.

[*From the* PROCEEDINGS *of the* ROYAL SOCIETY, *January* 15 *and March* 26, 1863.]

The condition in which fibrin exists in the blood and other fluids, and the deviation in quantity and quality in certain cases of disease from that of normal blood, has been to physiologists a subject of great interest. From the close resemblance of fibrin to albumen, I was induced to undertake a series of experiments, which appear to me to have some value in determining the conditions under which fibrin is derived from albumen, and which have resulted in the discovery of the general principle by which the direct conversion of albumen into fibrin may be effected. On referring to Lehmann's "Chemistry," in which the analyses of albumen and fibrin are quoted, it will be observed, on comparing them, that the difference appears to be the substitution of 1·5 part of oxygen per 100 for a similar amount of carbon, hydrogen, nitrogen, sulphur, phosphorus conjoined.

The following are the analyses quoted :—

Albumen.		Fibrin.
53·5	Carbon	52·7
7·0	Hydrogen . . .	6·9
15·5	Nitrogen . . .	15·4
1·6	Sulphur . . .	1·2
0·4	Phosphorus . . .	0·3
22·0	Oxygen . . .	23·5
100·0		100·0

The analyses made by Scherer give comparatively the same results.

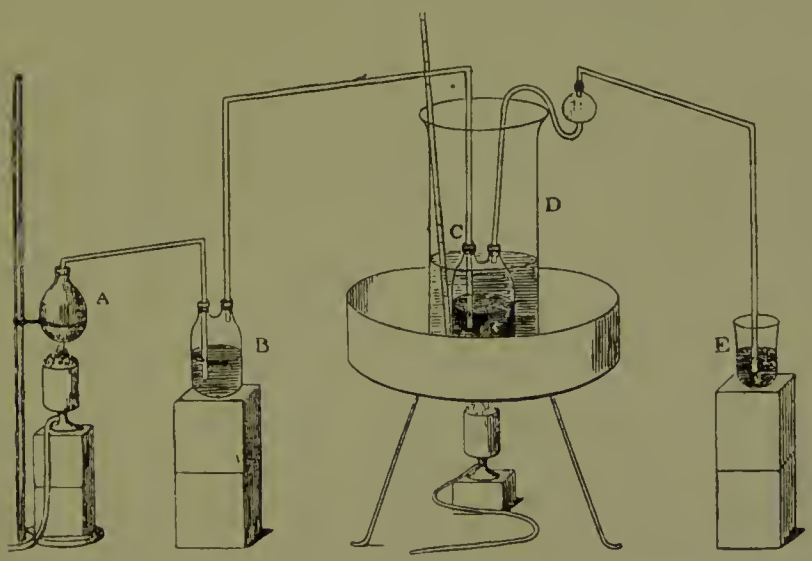
From these analyses I was induced to make some experiments to endeavour to convert albumen into fibrin by the direct addition of oxygen gas, by which I anticipated that not only might the oxygen be imparted

to the albumen, but also that the other elements might be oxidized and carried off.

In my first experiments I used blood from which the fibrin had been carefully whipped during the period of its coagulation, so that the serum might contain as many blood-cells as possible, upon the supposition that the cells would afford a large amount of surface to the action of the gas.

The serum, after being whipped, was permitted to stand for twenty-four hours, that any fibrin which it might contain, and which had not coagulated during the process of whipping, might do so.

The apparatus used in all cases will be easily understood by referring to the annexed diagram. It consists, first, of a copper flask containing black oxide of man-



ganese, from which the oxygen was slowly given off by the action of heat,

The gas was conveyed thence by tubes into a wash-

bottle B (containing a dilute solution of potass), for the absorption of impurities.

From the bottle B the gas passed into the flask C, which contained the defibrinated blood. This flask was placed in a vessel (D) containing water at a temperature varying between 95° to 100° Fahr., and I had no difficulty in preserving that heat continuously by a small gas-flame placed under a sand-bath. After the gas had escaped from the blood, I generally passed it through a second portion of defibrinated blood contained in another vessel (E).

For all these experiments pig's blood was invariably chosen, on account of its richness in blood-cells.

My apparatus being ready, and oxygen being slowly given off, the whipped blood, from which every particle of fibrin had been previously removed, was introduced into the flask C.

The blood employed was arterial, and not venous. At first the bright scarlet colour of the blood increased somewhat, but after twelve hours the bright scarlet began to assume more the colour of venous blood ; the cells at the same time began to shrivel. From this time the blood began rapidly to grow darker and darker, when, after thirty-six hours, it was almost black*.

Virchow has shown that, by acting on the hæmatin contained in the blood-cells by acetic acid, and subsequently boiling it, a substance is formed to which he gives the name of hæmine, which he considers to be a product in an intermediate stage between hæmatin and

* Crawford, about fifty years back, found that, after immersing animals in hot water, no difference could be discerned between arterial and venous blood.

pigment. The black substance formed by oxidation may probably be found to be analogous to, if not identical with, Virchow's hæmin. I found in this blood, at the end of thirty-six hours, small masses, which had, under the microscope, the appearance of fibrin. A small portion of the same blood as that used in the experiment was set aside till the completion of the experiment, when it was examined, but no fibrin was found.

Likewise in the glass E, although the gas was passed through it without heat, no fibrin was found, proving that temperature had also an effect on the production of fibrin. The experiment was repeated many times: in all cases the blood assumed the black colour, but I did not invariably find fibrin.

The appearance of fibrin in some cases, and the non-appearance in many others, seemed at first sight to be inexplicable, though I shall be able to demonstrate, in a later portion of this paper, that the result may be explained upon the hypothesis that the alkaline salts were in relative excess in those cases where the fibrin did not appear.

In my next series of experiments, the white of an egg was added to about 4oz. of the defibrinated blood. The egg-albumen at first had a tendency to separate and float at the top of the blood-serum, although well agitated together. In these cases the blood assumed the same dark colour as when it was subjected to experiment alone, though it did not appear until after the serum and egg-albumen had completely coalesced, which took place about ten hours after the subjection to temperatures between 95° and 100° Fahr., and the action

of oxygen gas. At the end of thirty-six hours, the time when the experiment was stopped, masses of substances were found floating, and also adhering to the bottom and sides of the vessel. These clots were in sufficient quantity to be collected and washed in the filter to free them from blood-cells and other impurities. The washed portion, under the microscope, had the distinct appearance of fibrin.

In cases where the albumen had not sufficient time to be mingled with the blood, little or no fibrin was formed. The time occupied for its absorption varied from about ten to twenty hours.

In the experiments which I conducted with albumen alone, I experienced at first some difficulty in obtaining the albumen perfectly pure, on account of the presence of chalazæ and other foreign matter. To obviate this difficulty, I found that by adding one drop of glacial acetic acid to every white of egg employed, and then by well beating up the albumen, I obtained, on subsequent filtration, a clear solution which gave to litmus-paper a slightly acid reaction. On placing this transparent albumen in the ordinary apparatus, I found, after the passage of oxygen gas for four hours at the temperature before stated, that fibrin began to be formed. I found that, by placing coils of platinum wire in the albumen whilst undergoing oxidation, the formation of fibrin was not only greatly facilitated, but its subsequent separation from the rest of the albumen was accomplished with greater ease, as the fibrin hung in threads upon the platinum wire. When platinized platinum was used,

the formation of fibrin, as might have been expected, was slightly improved.

Fibrin produced artificially in these experiments, and especially that formed on platinum wire, had a beautiful and regular arrangement, mostly being deposited in parallel lines. The fibrin likewise was whiter, and had a more delicate consistence than the common fibrin in blood.

I next tried the effect of adding a small quantity of a strong solution of ammonia to the albumen, which had naturally a slightly alkaline reaction; and then it was subjected to the influence of a current of oxygen in the same manner as in the preceding experiments. I found that fibrin was formed to a much smaller extent than when acid albumen was employed. The ammonia in all cases appears to be driven off to some extent by the oxygen, but was never entirely removed. The fibrin in this case formed on the surface of the liquid, and did not appear to be dissolved as the experiment was progressing. It is worthy of particular observation that fibrin was formed in the liquid which still contained ammonia in appreciable quantity.

My father suggested to me that it would be desirable to try the effect of the decomposition of water by electricity on albumen, as by that process the effect of hydrogen and oxygen in a nascent state is presented to different parts of the same fluid. For the purposes of this experiment I employed four cells (of the test-tube form) of Smee's battery, in which the negative pole consisted of a platinized platinum wire. This battery generated a continuous, but feeble, current of electricity;

and the smallest perceptible bubbles were evolved from the platinized platinum wire when in operation for the experiment.

The albumen was placed in the decomposition trough, where a very large positive pole was employed, but a smaller negative one, and the temperature was maintained as in former experiments. After the passage of the electric current for some time, the positive pole of the decomposition cell was coated with a hard gelatinous mass, which, being immersed in water at 90° Fahr. for a few hours, unravelled itself into long fibres, which had, under the microscope, the appearance of fibrin.

On the negative pole, however, a frothy deposit alone was formed; but great care must be taken to stop the experiment before the products of the two poles grow together, to which they have a great tendency. The moment this takes place the albumen begins to coagulate, and in a very short time the whole becomes converted into an almost semi-solid mass. The fibrin is not so perfect when made by this method, and is much more difficult to form than when made from neutral or slightly acid albumen by the ordinary process of oxidation.

In my experiments with egg-albumen to which a solution of potass had been added before it was subjected to the action of oxygen, the temperature ranging between 95° and 110° Fahr., no fibrin was found when the experiment was stopped.

In one case oxygen was passed trough a solution of potass and albumen for three days and nights, and yet not the slightest trace of fibrin was found. The albumen

became of a dark red hue, but two days after the experiment ceased it resumed its normal colour. A few transparent hard substances were found, insoluble in water and weak acids which had separated from the albumen. A few other small white substances were noticed, which had all the appearance of carbonate of lime, and which were soluble in acid. Albumen was then mixed with gastric juice, and kept at the normal temperature of the body for the space of twelve hours, to produce artificial digestion, when it was subjected to experiment. I should here state that the gastric juice was procured from a dog, which had a fistulous opening made into its stomach by Professor Savory. All symptoms of inflammation and irritation had fully ceased; the dog, in fact, was in perfect health, and beginning to get fat, when the gastric juice was procured; so that the latter must be considered as healthy gastric juice. From the dog large quantities of gastric juice were obtainable; and I have to tender my best thanks to Professor Savory for his great kindness in placing whatever I required at my disposal. After the albumen had been digested for twelve hours and filtered, that the solution might be perfectly clear, it was subjected to the action of oxygen for a few hours, when fibrin was formed, though not in so large an amount as in albumen to which one drop of the glacial acetic acid had been added. The filaments of the fibrin, however, were of a more delicate constitution.

From a consideration of the above results, I thought that fibrin might be formed from the albumen which, after digestion with gastric juice, had passed through a

membrane made of the parchment paper of Messrs. De la Rue and Gaines. In some experiments* to which I had been led from a study of Professor Graham's elegant researches on dialysis, and which I had formerly been conducting, on the passage of various fluids through membranes, it was observed that albumen, after digestion with gastric juice, dialysed to a certain extent. Three ounces of albumen were digested for the space of twelve hours, at the temperature of the body. It was then placed on the dialyser: it should be remarked that gastric juice does not coagulate the albumen during its conversion into albuminose.

The digested albumen was kept for ten hours on the dialyser at the temperature of 98° to 110° Fahr.

The water (one and a half pint) into which the digested albumen had passed was concentrated at a temperature of not more than 80° Fahr.; and the concentrated solution being afterwards oxidized, I found that fibrin was formed, notwithstanding the changes it had undergone by digestion, which had rendered it capable of dialysis. During the process of passing oxygen into albumen, I found that carbonic acid was evolved. This was ascertained by passing the oxygen, after it had escaped from the albumen, through lime-water. I also found that phospheric acid was evolved, by subjecting the effluent oxygen to the molybdate-of-ammonia test. Carbonic acid and phospheric acid were

* These experiments, although carried on upon an extensive scale, are not quite in order for publication in detail; nevertheless I may state that, after artificial digestion, pure albumen, coagulated albumen, cheese, and, most remarkable of all, cod-liver oil were capable of passing through the dialyser into water to a large extent. I trust on a future occasion to elucidate this curious action.

also found when blood-serum was used, by the same tests as those employed when egg-albumen was the material used for experiment. In some cases common air was driven through albumen in the place of oxygen, at a temperature between 95° and 110° Fahr., and then I found the formation of fibrin differed but little from the quantity produced when oxygen alone was used. To ascertain whether the formation of fibrin was due really to oxygen alone, I tried hydrogen gas in the place of oxygen or common air, and at the same temperature. When hydrogen was passed into blood-cells sulphur was evolved. This was detected by passing the hydrogen, after it had traversed the serum, into a solution of lead-salt, and also by suspending over the serum strips of lead paper, when they soon became blackened by the sulphur.

When egg-albumen was employed instead of the blood-serum, sulphur was again detected.

Fibrin was not formed by the action of hydrogen on blood-serum or egg-albumen, although in some cases the hydrogen was passed continuously for forty-eight hours through the fluids. The action of carbonic acid gas on egg-albumen under the same condition of temperature produces no fibrin, but sulphur was again detected by suspending strips of lead paper over the albumen, which in a few hours became tinged.

The same result was obtained when defibrinated blood was used; but in this case, in addition to the sulphur, a minute trâce of phospheric acid was found. Not the slightest trace of fibrin was detected.

I conceived, from the result of my experiments on the oxidation of albumen, that, if oxygen was passed into milk, fibrin might be formed, from the fact that the analyses of albumen of egg, and the casein which the milk contains, differ little from each other, and because the analysis of the milk of an animal, a few days before and after parturition, shows that albumen is found in the place of casein. On subjecting, however, milk to experiment, no fibrin was found after the lapse of twenty-four hours.

This may be due to either of two causes; first, the casein in the milk may not be in a fit state for undergoing the change before it has been acted on by the various digestive secretions, or, secondly, because in the dilute and fluid state in which it occurs in milk it does not offer sufficient resistance to the passage of the bubbles of oxygen to retain the gas sufficiently long for each bubble to have time to produce an effect. In all my experiments I have found (other conditions being equal) the slower the bubbles passed through the liquid material, and the more viscid the fluid was, the greater was the amount of fibrin produced. This may possibly in some degree account for the non-formation of fibrin when oxygen was passed through milk. I tried the effect of oxygen upon fresh grape-juice, but was unable to form any fibrin from it. Further experiments are required upon various vegetable juices.

I next experimented upon the oxidation of gluten, which was obtained from wheat-flour by the ordinary method. This was digested in gastric juice for twelve hours, and then filtered. After the clear liquid had been

subjected to oxidation for some hours, small threads of a substance were formed. When a portion of this was placed under the microscope, no difference could be detected between it and ordinary fibrin.

From these experiments, it seems to me that the following conclusions may be drawn :—

First, that fibrin is produced by the direct action of oxygen on albumen.

Secondly, that the alkalies and alkaline salts prevent the appearance of fibrin when albumen is acted upon by oxygen.

Thirdly, that the formation of fibrin from albumen is accompanied by the evolution of sulphur, phosphorous, and carbonic acid.

Fourthly, that a temperature ranging between 98° and 110° Fahr. promotes the artificial formation of fibrin.

Fifthly, that the greatest amount of fibrin appears when the albumen is neutral or slightly acid.

Sixthly, that the viscidity of the material employed promotes the formation of fibrin.

Seventhly, that albumen, artificially digested in gastric juice, produces fibrin by its subsequent oxidation, even after dialysis.

Eighthly, that gluten dissolved in gastric juice, and then oxidized at the ordinary temperature, yields fibrin.

The formation of fibrin in the human body, and its relation to albumen, has long been a vexed question. I venture to put forward these experiments in connexion with this important and interesting inquiry.

POSTSCRIPT.

Since the paper was read before the Royal Society the following additional facts have been elicited. Fibrin was obtained from serum when subjected to oxygen gas, when acetic acid was added to it, although another portion of the same serum had refused to yield it without that addition. In this experiment the acetic acid should be added until the serum is either neutral, or produces a slightly acid re-action on test-paper. Care must be taken in these experiments to prevent the temperature rising too high, for a coagulation then takes place. If blood-cells be present in the serum, the addition of acetic acid attacks the cells in preference to the alkalies of the serum ; and on subsequent exposure to a temperature of 100° F. during the period it is under the influence of oxygen, the whole is transformed into a semi-solid mass.

It is a curious fact that serum which has been placed on a dialyser for the removal of the salts by Graham's method was not improved in its power of producing fibrin over serum which had not been submitted to that treatment previous to its oxidation. On the other hand, albumen purified from salts by Graham's method, and then subjected to the influence of oxygen, yielded the largest amount of fibrin. By this method it is most probable that I should have been able to have transformed the whole of the albumen into fibrin, had not an accident unfortunately brought the experiment to a termination. Nevertheless, although the experiment

was not continued long, half the albumen was changed into fibrin.

When experimenting upon albumen nearly free from alkalies and alkaline salts, great care must be taken to keep the temperature as low as possible. I found that a temperature between 80° and 90° F. was the best, for above 98° the albumen had a very great tendency to coagulate.

When albumen was placed in a tube which contained about an equal bulk of oxygen, and in which a platinized platinum wire had been inserted extending the whole length of the tube, to facilitate the action of the oxygen on the albumen, and which tube was subsequently sealed and placed in a water-bath of 98° F., no fibrin made its appearance even after the lapse of 36 hours, but in its place a small quantity of an amorphous material subsided to the bottom of the tube. When, however, a tube of similar size was filled with albumen having free excess to the air, and then placed on the same water-bath for an equal length of time, on the surface of the albumen which this tube contained small masses of fibrin were formed, which had an appearance identical with that of blood-fibrin under the microscope, giving a conclusive proof to my mind that, during the formation of fibrin by the action of oxygen on albumen, a volatile constituent is formed and carried off by the excess of oxygen which passes into the albumen in solution.

The following are the chief physical and chemical properties of the fibrin artically formed by the action of oxygen on albumen :—

It has a lighter specific gravity than albumen, being always found floating on the surface of the albumen, provided it is free and not entangled or attached to the side of the vessel or platinized platinum wire that has been inserted in the albuminous solution.

It has a fibrinated appearance under the microscope, and is capable of being teased out into filaments in the same manner as blood-fibrin.

Acetic acid completely dissolves it after some time.

Soda and potash cause it to swell up and dissolve. Concentrated solution of ammonia, after the lapse of some hours, causes the fibrin to swell up in a gelatinous mass, similar to that which occurs when blood-fibrin is submitted to the same reagent.

A hot or cold solution of nitrate of potash does not dissolve it when it is digested in that menstruum for some hours.

With Millon's test it becomes of a brick-red colour.

With nitric acid a bright yellow colour became visible.

Fibrin heated with hydrochloric acid gave a blue colour, and subsequently dissolved, giving a blue tint to the liquid.

An acid solution of acetate of lead caused both blood-fibrin and fibrin artificially prepared to swell up and become translucent after digestion for a certain period.

ON

ORGANIC SUBSTANCES

ARTIFICIALLY FORMED FROM ALBUMEN.

BY

ALFRED H. SMEE, F.C.S.

In a former paper which I had the honour to submit to the Royal Society, I showed that fibrin was formed by the passage of oxygen through albumen, provided a temperature of 98°F. was maintained. It was then observed that a slightly acid state of the albumen, or the absence of the alkaline salts, was found to be most favourable to its formation. I noticed also that ammonia had little effect in preventing the formation of fibrin, but after a lapse of a short time caused it to swell to such a degree that its microscopic characters could no longer be determined. It was observed that albumen acted on by gastric juice and passed through a membrane still had the capacity to form fibrin in small amount.

Since the publication of that paper, I have conducted the following experiments in addition to those before mentioned. I submitted some of the fluid drawn off from a spina bifida to the action of oxygen and heat in the ordinary manner; after the lapse of a few hours it yielded a substance which, under the microscope, presented all the characters of fibrin.

I tried to obtain fibrin from the urine in two cases in which it was highly albuminous. The urine was so loaded with albumen that it became almost solid by heat. I never have been able to transform this variety of albumen into fibrin, although the experiment was tried in many ways. I expect that on further investigation it will be found that the albumen found in urine (in most cases at least) is a substance not capable of further development.

The next experiment which I have to describe is to my mind one of the most beautiful exemplifications of

the artificial formation of organic bodies under physical laws, producing results similar to those which we observe under certain circumstances in disease, the changes being produced by the action of a gas on a second body separated by a membrane, and having to traverse it before the chemical changes can be effected.

I passed a current of oxygen gas through a small portion of perfectly clean intestine, with the peritoneal coat attached. The intestine was placed in an albuminous fluid at a temperature of 98°F.; at the end of twenty-four hours I found the intestine completely invested with minute fibrinous outgrowths, similar to those seen on the intestines of persons who have died at the earliest stages of peritonitis.

It is worth noticing that although these fibrinous outgrowths take place when the peritoneum of the intestine remains, yet if this coat be stripped off they take place to a very limited extent. In many cases no outgrowths appear, even where the conditions of the experiments are equal.

It appears to me that the tendency of fibrin to be deposited on serous membranes, under favourable circumstances, may throw some light on the frequency with which we find the surfaces of serous membranes (for instance the pericardium) so often coated with fibrinous outgrowths.

If hydrogen is passed through albumen to which a small quantity of potash has been added sufficient to ensure a slight excess of alkali, after a lapse of some time a dense hard horny mass will be observed, especially at the point where the hydrogen comes into

contact with the albumen; in fact the growth of the substance often clogs the tube to such a degree that the hydrogen is prevented from further passing through it. It also has a tendency to grow upon platinized platinum when placed in the albuminous fluid whilst the current of hydrogen is passing. The time required is, as a rule, about four days; a temperature of 98°F. rather favours its formation, but it is not absolutely necessary to its production.

The following are the chief chemical and physical reactions of the substance formed by hydrogen.

It is heavier than albumen, always sinking to the bottom of the vessels. It is hard, tough, semitransparent, homogeneous, and slightly elastic. It swells up in cold water, and dissolves to a limited extent. The extent of its solubility is less the longer the time occupied for its formation. It is more soluble in hot water. Peroxide of hydrogen is not decomposed by it.

The watery solution is not coagulated by boiling; it is, however,precipitated by chlorine. Hydrochloric acid does not form a blue solution with excess of that reagent. Bichloride of mercury and bichloride of platinum, after a lapse of some time, precipitate it. Tannic acid, alcohol, acetate of lead, sulphate of the peroxide of iron, and alum also precipitate it from its solution. It is turned yellow by nitric acid and heat. It likewise contains a small quantity of sulphur. Chondrin behaves in a similar manner, in its chemical and physical relations, to the substance thus artificially produced, and hence I propose to call it "artificial chondrin."

In carrying out these experiments, I found that a very nice method of obtaining a constant and equal amount of hydrogen gas was by collecting hydrogen formed at the negative pole of a one-cell battery, and passing the hydrogen thus formed directly into the albumen. The amount of hydrogen required was regulated by increasing or diminishing the size of the negative pole.

This form of apparatus will constantly remain a week or more in action without any appreciable alteration in the quantity of hydrogen evolved.

It may be well to describe the construction of the apparatus used. I first take a common precipitating glass, and place in it a few pieces of zinc with a little mercury to amalgamate it. I then take a tube about $\frac{1}{4}$ inch in diameter, and bent in two places at a right angle; into one end I insert a platinum wire, this end I place in the glass containing the zinc; the other end I place in the vessel containing the albuminous fluid. Dilute sulphuric acid is then added to the zinc. When contact takes place between the platinum wire and the zinc, a constant stream of hydrogen is given off from the platinum wire. The amount of hydrogen required can be regulated by making a larger or smaller surface of the platinum come in contact with the zinc. The amount of oxygen which is carried over is very limited, provided a tube is used of $\frac{1}{4}$ inch diameter; but when a tube of $1\frac{1}{4}$ inch is used, a quantity might pass sufficient to interfere with the experiment.

The amount of oxygen at times thus carried over when the large tube is used is so great, that a change in

the products may take place and fibrin may be formed in the place of the chondrin, provided the albumen is not over alkaline.

As fibrin was formed by oxygen, and this new substance analogous to chondrin by hydrogen, it occurred to me that these two substances might be formed simultaneously by a simple-cell voltaic arrangement. For this purpose I took a tube with one end closed by parchment paper, or sometimes by animal membrane, filled it with albumen which had been made slightly acid by acetic acid, and inserted it into a small vessel containing albumen to which a small quantity of potash or soda had been added. I then connected the two fluids by means of a platinum wire, so that one side might become a positive and the other a negative pole. Considerable action took place after the lapse of some time, when upon examination I found the albumen in the tube was changed, not into the fibrillated fibrin, but into a granular material. The other pole, or rather the alkaline albumen, was changed into a substance which behaved with various reagents in different ways. In some cases it was a tough, ropy and viscid substance which was coagulated in water by a solution of acetate of lead, was insoluble in acids and in alcohol, and very slightly soluble in alkali. At other times I have noticed a substance formed having very much the appearance of the expectoration of bronchitis; and at other times the dense hard substance analogous to chondrin in its behaviour with reagents was formed.

The various states of the material into which albumen is converted appear to be influenced by the

nature of the alkali employed and by the relative size of the negative pole. The temperature should be as nearly as possible constant during the time the experiment is being conducted. The amount of the surface of membrane interposed appears to have very little influence over the products. When soda was the alkali employed, the viscid and frothy mucus-like product was more frequently obtained.

The amount of water present appears to have a very decided influence on the product formed. When the viscid and frothy material is produced, it appears to form quicker than the hard and dense chondrin. The temperature of 98°F. appears to favour the production of the chondrinous material; but I must admit I have sometimes made all the varieties, the viscid, the frothy, and also the chondrin, at much lower temperatures.

In one case I succeeded, after many experiments, in obtaining from the acid pole, by keeping it at a temperature of 98°F., fibrin of the fibrillated form, but the greater portion of the albumen at this pole was converted into the granular form. The alkaline pole formed pretty constantly the dense hard artificial chondrin.

When hydrogen was passed through serum, after the lapse of a day or two a tough elastic product was obtained.

In experiments tried by passing hydrogen through albumen greatly diluted with water, I found, after the lapse of a few days, a flocculent deposit very similar in appearance to the deposit of mucus which often takes place when urine is allowed to stand a short time. This

point, however, requires further investigation. I tried also the effect of passing hydrogen through a portion of intestine inserted into an albuminous fluid. I have not as yet been able to form either the dense hard or viscid frothy substance by this method. I repeated the experiment for the formation of fibrin from albumen, by decomposing the water of its composition by electricity. I must admit this is the most difficult, troublesome, and unsatisfactory of all the methods I have employed. I find that the great tendency of the poles to form different substances on them, and the great rapidity with which they grow together, lead, without the greatest care, to the belief that two different substances differing only in density, are formed at one and the same pole, so intimately blended are they together. Thus I was led to believe at first sight that a dense hard substance was formed at the oxygen end, and not until I had repeated the experiment many times did I discover that the substance belonged to the hydrogen and not to the oxygen pole, and had grown across from one pole to the other.

I have obtained on several occasions fibrin and chondrin at the same time by conducting hydrogen and oxygen derived by the decomposition of water by voltaic electricity through separate tubes. The oxygen passed into slightly acid albumen formed fibrin ; the hydrogen passed into alkaline albumen formed either the chondrin or else the frothy and viscid material. The temperature was kept up at 98°F. in these experiments. On one occasion, however, I happened accidentally to reverse the current (that is to say, the hydrogen was passed into

the acid, and the oxygen into the alkaline albumen), when no chondrin or fibrin was formed.

The following conclusions I have arrived at after the study of the influence which oxygen and hydrogen gases exert upon albumen when submitted to their action separately at a temperature of 98°F., the normal temperature of the living body. Albumen under the action of oxygen forms, after the lapse of a longer or shorter period, fibrin. The fibrin thus artificially produced is of three distinct varieties, viz., 1st, the granular form; 2nd, a form allied to lymph incapable of being unravelled into fibrils; lastly, the true fibrilated fibrin. The law which appears to regulate the state into which the albumen is converted, as far as my observation has gone, is one of molecular aggregation, similar to the electric deposit of metals, as the slower the fibrin is formed the more organised is it in substance.

I have observed that when fibrin is rapidly formed it is almost always produced in the granular state; this is particularly the case with fibrin formed from albumen by the decomposition of the water of its composition by voltaic means.

Lymph I consider to be imperfectly formed fibrin more highly developed than the preceding or granular form. It is possible for this artificially formed lymph, under favourable circumstances, to assume a more organised appearance.

I have no doubt that the fibrinous outgrowths on the intestine would have become larger and more developed if the experiment had been carried on for a sufficient length of time. In fact almost all the fibrin

formed round a platinum wire inserted into albumen is at first covered by outgrowths of a soft structure. These outgrowths, at the earliest period of their formation, do not under the microscope present any appearance of fibrils. After the lapse of some time they appear to undergo condensation, and then to organize to such an extent that it would be difficult at first sight to determine whether the substance might not be a portion of fibrous tissue.

The alkalies, with the exception of ammonia, prevent entirely the formation of fibrin. Ammonia, although it does not retard its formation, dissolves it after the lapse of a short time. The acids and absence of alkaline salts favour its formation. The opposite, however, is the case with the hydrogen products, as an alkaline state favours their production.

The action of hydrogen on albumen, as far as my investigations have as yet proceeded, forms substances analogous to chondrin and mucin. I believe that the organic substances, chondrin and mucin, products formed in a living organism, are very closely allied to one another, if not varieties of the same substance, differing only in their mode of aggregation and stages of development, and the amount of water in their composition.

Of the exact mode in which hydrogen acts on albumen we are at present ignorant. I have noticed that in some experiments sometimes one, sometimes the other product was obtained, even when the same influences were apparently acting on experiments conducted at the same time.

Considering the important physiological part that fibrin, chondrin, and mucin play in the living body, the production artificially of substances analogous in their behaviour with reagents to those products formed in a living organism will, I trust, be taken as a sufficient excuse for submitting to the Royal Society a paper so obviously deficient in many parts, but which, nevertheless, it would require a vast amount of both time and labour to carry one step further.

ON THE

PHYSICAL NATURE

OF THE

COAGULATION OF THE BLOOD.

BY

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Read at a Meeting of the Royal Society.

The cause of the coagulation of blood fibrin has long been a vexed question among physiologists. In bringing this subject under the notice of the Royal Society it is my intention, first, briefly to review the various theories which have been held at different times, and, then, to state those views on coagulation which have been enforced upon my mind by direct experiment, and also by the behaviour of colloidal substances analogous to fibrin.

Hunter, the great upholder of vital force, thought that coagulation of the blood was an act of life, and was analogous, to some extent, to the contraction of a muscular fibre. Hewson, a contemporary, in opposition to Hunter's views, noticed that blood could be kept fluid for months by addition of certain neutral salts. This experiment has been urged as conclusive evidence against Hunter's theory of coagulation; for it is impossible to conceive that vital power could last for such a length of time. Gulliver found that blood remained fluid for one year on the addition of nitre, yet still retained its power of coagulation on the addition of water.

Coagulation was held by other physiologists to depend upon the stasis of the blood in the vessels; and they pointed to the coagulum at the point of ligature in an artery which had been tied as the result of the stasis.

Again, exposure to air was stated to be necessary for the formation of a coagulum; and it was supposed that something, probably of a gaseous nature, was given off from the blood at the time of coagulation.

The evolution of carbonic acid from the blood was considered to be the cause. Dr. Richardson considered that fibrin was held in solution by free ammonia which escaped from the blood on exposure, when the fibrin began to coagulate.

In an experiment which I related in my paper on the artificial formation of fibrin from albumen, I demonstrated that ammonia, in quantities greater than could ever be found in the blood of the living body, might be added to albumen; nevertheless, when this albumen was submitted to the action of oxygen at a temperature of 98° fibrin formed, although it was afterwards slowly dissolved.

Lester pointed out in one of his experiments, that, on carefully neutralizing the blood with acetic acid, no alteration was made in the power of its coagulation. Coagulation, however, was observed to take place more rapidly *in vacuo*, giving some justification to the views of those who hold to the theory that the blood exhales from itself some volatile principle at the time of coagulation.

Heat likewise is said to favour, and cold just above the freezing point to retard, coagulation.

In asphixiated animals coagulation was found to be retarded. This fact was regarded as evidence that carbonic acid kept the blood fluid.

Astley Cooper and Thacknot thought that the blood-vessels exerted a specific influence in actively preventing the coagulation of the fibrin in the blood. Brücke supported this view. He found that the blood of a turtle injected into an empty heart remained fluid

for many hours, whilst some of the same blood exposed in an open vessel coagulated in a few minutes. Lester found that, on inserting a tube into the circulating system, fibrin, in a short time, separated from the blood, the coagulum coating the internal surface of the tube; but that, after a time, fibrin ceased to separate from the blood. This was a case of blood coagulating in a sealed vessel and disposed, to my mind, of the exhalation theory of coagulation. Morrant Baker, in the 1st Vol. of the St. Bartholomew Hospital Reports, remarks that the blood, in blood tumours, remained fluid, and that the fibrin in most cases had separated from the liquor sanguinis. He further remarked that the internal surface of the tumour was coated with a coagulum which had apparently undergone organization, and was, in tumours of old duration, hard, and like fibrous tissue. The specific gravity of this blood had fallen from 1,052 (normal blood) to 1,020. Sometimes, however, a portion of blood coagulated when the tumour was opened. He thinks this is due to bleeding from the small vessels which have been punctured by the incision, the fresh blood mixing with the blood of the tumour, and a second coagulation takes place. I think this phenomena may be explained by Lester's tube experiment, where he shews that when blood is first effused, or passed into or through a tube which had not previously been coated with blood fibrin, the fibrin separates into a coagulum, this coagulum then undergoes organization into fibrous tissue; but, if on a second hæmorrhage taking place into a blood tumour, or if more blood is passed through the fibrin coated tube,

the fibrin will not separate from the liquor sanguinis. When a needle or wire is inserted into a blood vessel whilst the blood is circulating it acts as a foreign body, and it soon gets coated with a fibrinous deposit; upon this principle is founded a treatment for the cure of aneurism.

Lester has demonstrated that the blood will remain fluid in the jugular vein from 24 to 48 hours after death, provided the vein has been tied just before or just after death, but when the blood is turned out coagulation immediately takes place. Buchanan has shewn that the fluid from a hydrocele yielded a coagulum on the addition of blood serum, although each fluid, without the addition of the other, might be kept separate for any length of time without coagulation taking place. Schmidt also held the same view, but considered that it required a fibro-plastic substance of the nature of globulin to combine with another substance which he termed fibrogen.

Lionel Beale has studied the phenomenon of coagulation under a magnifying power of upwards of 2,000 diameters ($\frac{1}{50}$ inch). The first change he noticed was a film-like appearance in the liquid sanguinis, especially in the track of the red corpuscles as they slowly traversed the field. This film-like appearance was succeeded by delicate threads apparently corresponding with the track of the blood-cells, these lines gradually increased in density and refractive power.

He thinks that this coagulable matter exists, in the first instance, as a diffused plasma, probably formed from the white cells, which, gradually separating from

the serum, contracts, acquires density, and thus becomes visible under the microscope.

During coagulation the red cells become stellate, refract more highly, lose diameter and fluid; at which time probably globuline escapes.

Lastly, when blood is stirred up with twigs, coagulation proceeds more rapidly.

Having thus briefly reviewed the principal theories held by physiologists, I now venture to submit that view which, in my opinion, best accords with all observed facts.

From a careful review of all the circumstances of the case we may fairly consider that the coagulation of the blood takes place in obedience to a purely physical law, namely, the power of soluble colloid matter, whether organic or inorganic, to pectize, or in other words, spontaneously to coagulate. In order that I may illustrate this view of the coagulation of blood, I must ask the Fellows of the Society to travel with me into the paths of inorganic chemistry, especially calling attention to Graham's experiments on colloid matter published in his paper "on liquid diffusion applied to analysis."

The act of pectization of a colloid body may be regarded as the equivalent of the act of crystallization of a crystalloid body.

Take for instance a solution supersaturated with sulphate of soda, it will remain fluid for days. Stir it, or even drop a particle of dust into the fluid, it will instantly begin to crystallize.

In this case we observe a perfect analogy between the action of a particle of dust which determines the act of crystallization in this solution and that of the wires or twigs which, when applied to blood, produce a rapid formation of a coagulum. No one can say that this crystallization of the sulphate of soda was an act of vitality.

Graham has shewn that the essential characters of all colloids are to form a jelly and not to dialyse. This jelly he regards as the pectous or insoluble state ; whilst the soluble state of a colloid he regards as the peptous. An inorganic colloid in the pectous condition is a vitreous mass, homogeneous and perfectly structureless, in which state it apparently remains an indefinite time, gradually losing water and becoming more and more dense, and probably after the lapse of years it is capable of undergoing transformation into a more or less crystalline state. In nature the structureless flint may be found gradually being converted into the crystalline. When an organic colloid assumes the pectous condition, it contracts and crushes up into fibres. This is the case with fibrin, albumen and gluten.

Graham has also shewn that all organic colloid substances have high chemical equivalents, and are at the same time, chemically inert in the ordinary sense, but possess a compensating activity from other physical properties. Crystalloid bodies appear to shut out external impressions, whilst colloids possess properties, to use Graham's own words, which enable them to become the medium of diffusion like water itself. Another characteristic quality of colloids is their

constant mutability. Their existence is a continual change. A fluid colloid may assume a pectous modification, and often passes, without any visible external influence, or even of internal change, from the first (the fluid) to the second (the pectous) condition. Colloidal substances, such as gelatine which gelatinize, but still retain their power, again become fluid by heat and are soluble in water, cannot be regarded as assuming the pectous condition, but the gelatinous.

Graham has demonstrated that when a soluble colloid has assumed the pectous or coagulated condition it cannot again *per se* become fluid. In the case of certain colloids, however (silicic acid, for instance), the addition of a small quantity of an alkali to the jelly causes it to again liquefy. If the fluid containing silicic acid *plus* the alkali is placed upon a dialyser, the alkaline salt is removed, leaving the silicic acid in a pure and soluble state, in which condition it will remain for some time, when it will again assume the pectous state. The addition of the alkali, however, appears to have had no chemical action on the silicic acid jelly, but only changed its physical condition from the pectous to the peptous or fluid state. On the other hand, the act of gelatinization may be repeated *ad infinitum*, as the gelatine may be melted over and over again.

I must now direct attention to Graham's experiments on the behaviour of hydrated silicic acid, and to the analogous physical behaviour of film. Graham has shewn that hydrated silicic acid, in a state of great purity, can be obtained and held in solution, but cannot be preserved in that state for any length of time. It will

remain fluid for days, and even for a longer period, if it is in a sealed tube; but it will ultimately spontaneously coagulate and become insoluble. A concentrated (14 per cent.) solution assumes the pectous condition in a few hours. A 5 per cent. solution may be kept for some days. A 2 per cent. solution will keep two or three months; and a 1 per cent. will remain fluid even after two years.

The addition of solid matter in the state of powder to liquid silicic acid greatly favours the act of pectization, the solid matters apparently acting as a nucleus, like the dust in sulphate of soda in solution, and set up crystallization.

The addition of one 10,000th part of an alkaline carbonate to fluid silicic acid causes it to immeditely pectize. The silicates of the alkalies are themselves soluble in water; but no one would assert that the addition of an alkaline carbonate could have any other effect on silicic acid than that of a foreign body setting up a new physical condition, for no chemical action can possibly have taken place during the transition of the silicic acid from the fluid to the pectous state. Acids and other neutral salts likewise cause coagulation. Caustic ammonia, however, has no action on fluid silicic acid. Alumina likewise has the power of existing in the fluid and pectous state without the intervention of an acid; but soluble alumina is one of the most difficult substances to prepare owing to its unstable nature in the fluid state. A vessel washed out with ordinary water (which contains a trace of sulphate of potash) is sufficient to cause it at once to coagulate. The addition

of sulphate of potash, in the one case, or of an alkaline carbonate, in the other, cannot be said to have effected any chemical change in these colloids to cause them to pectize. I believe that neutral salts added to the fluid silicic acid act in a similar manner to the handful of twigs used for stirring up blood, as they act simply as foreign bodies.

Soluble peroxide of iron is more interesting to the physiologist than either soluble silicic or albumina, on account of iron being one of the constituents of the blood ; and it is more than probable that the iron in the red blood corpuscles is in a fluid state. Graham remarks that soluble peroxide of iron remains fluid for 20 days, provided it is in a weak solution and kept in sealed glass tubes, when it will suddenly spontaneously pectize without any apparent cause. Water containing 1 per cent. of hydrated peroxide of iron has the deep red colour of venous blood. This solution can be concentrated to a certain point, when it will suddenly pectize. The coagulum is a deep red coloured jelly resembling blood-clot. Graham remarks that the feeble circumstances which suffice to produce this change is highly suggestive of blood.

The following experiments which I have made upon fresh-drawn blood illustrate the manner in which fibrin pectizes in animal fluids. These experiments clearly demonstrate that the act of coagulation takes place in accordance with purely physical law.

On the addition of an equal quantity of a solution of sulphate of soda to fresh-drawn blood coagulation will not take place, and the blood will remain fluid an

indefinite time. The blood-cells however will gradually subside, leaving the liquor sanguinis containing the uncoagulated fibrin bright and clear. If some of this liquor sanguinis is placed in a dialyser and then the dialyser placed in distilled water, in the course of a few hours the sulphate of soda will dialyse out of the liquor sanguinis, and a thin gelatinous film of fibrin will be formed at first, in direct contact with the parchment paper of the dialyser. This film of fibrin will gradually extend and become thicker as the sulphate of soda slowly dialyses out of the solution; after the lapse of 10 or 12 hours the whole will have become one uniform structureless clot. This clot will, after some days, contract, squeeze out the liquor sanguinis, lose its structureless appearance, and crush up into fibres.

If a second quantity of the liquor sanguinis is placed on the dialyser which has been previously coated with fibrin jelly, the second quantity will require a greater length of time for coagulation to begin. This is especially the case if a cup-shaped depression has been made in the fibrin jelly for the second quantity of the liquor sanguinis. When the solution of sulphate of soda is added to the liquor sanguinis in excess, the time of coagulation is delayed in the direct ratio to the quantity of the sulphate of soda added to fresh-drawn blood.

If the fluid which is placed upon the dialyser contains not more than one part of the liquor sanguinis to 30 pints of the sulphate solution no pectization will take place, even after the sulphate has been removed by long-continued dialysing; and probably the fibrin remains fluid upon the dialyser sufficiently long to get

oxydised, and converted into some other substance. Upon this point I purpose making further investigation. The fibrin jelly formed by dialysing is dissolved slowly in caustic potash, leaving behind a small quantity of hexagonal crystals which are soluble in acetic acid. I have placed fibrin jelly which has been redissolved in potash upon a dialyser to remove the alkaline salt, but I have failed in every instance to get the film a second time to pectize.

I have observed a very curious property in fibrin jelly (which has been made from a dilute solution) of breaking up and becoming again fluid, and passing through the blotting paper filter used to separate the liquor sanguinis from the fibrin jelly. I can find no satisfactory explanation of this remarkable change, unless we accept the view that very minute causes are sufficient to determine the physical condition of colloid substances.

Dr. Goodman has noticed that albumen suspended in a ropy condition in cold water, coagulated after some time, became white, dense, insoluble, and finally fibrous. This change he regarded as evidence of the formation of fibrin from albumen. I have frequently repeated the experiment. I believe that no new substance is formed out of the albumen by this method, which I believe has only changed its physical condition from having its salts removed by dialysis, which causes the albumen to change from the peptous to the pectous state.

Having brought under the notice of the Society some of the principal characteristics of colloid, I will now proceed to a comparison between the behaviour,

physically, of the inorganic colloid silica with that of the organic fibrin.

In every essential point it will at once be recognized that these two dissimilar substances agree, and, at the same time, that there is no circumstance during the act of coagulation which cannot be explained by physical law.

The analogy between fibrin and silica in their physical behaviour will be best observed by comparing their properties together. 1st. Fibrin and silica colloidal substances are known to exist in the fluid as well as in the coagulated condition. 2nd. When either fibrin or silicic acid assumes the pectous state it is incapable of being *per se* redissolved, so as again to be able to spontaneously pectize. The existence of both these substances is a continual metastases: fibrin is a typical instance of this metastases. 3rd. All colloids in the fluid condition, whether of organic or inorganic origin, after an interval of time, longer or shorter according to their specific characters, spontaneously coagulate. 4th. This coagulation takes place without the intervention of any chemical agent which is capable of producing a change in that colloid. 5th. The condition of neutral salts to inorganic colloids in a fluid state (just as the falling of a speck of dust into the supersaturated solution of sulphate of soda favours crystallization) favours the coagulation of those colloids. The neutral salts in these cases must be regarded as foreign bodies. Possibly the white blood cells, altered in their physical condition by exposure to air, become as foreign bodies to the blood, and have a similar influence as twigs and rods used ordinarily to defribinate blood.

Lastly, the capacity of all colloids to remain in the fluid condition is greatly promoted. 1st. By the weakness of the solution (less than 10 per cent.); 2nd. By being contained in sealed vessels.

The time required by a fluid colloid to pectize apparently depends upon its molecular equivalent.

The fluid condition appears to be less stable in colloids with high molecular equivalents, and the act of pectizing takes place more rapidly and with less apparent cause, and apparently in direct ratio to the molecular equivalent of the colloid. Consequently, soluble peroxide of iron pectizes sooner than alumina, and alumina more rapidly than silica. Therefore fibrin, with a molecular equivalent vastly higher than either of these colloids, might be expected to coagulate almost immediately.

Occasionally masses of natural silica containing fluid are found in nature, of which I myself possess a remarkably fine specimen. These appear to me to have a great resemblance in their formation to that of the blood-tumours described by Morrant Baker. The enclosed fluid may be analogous to that in Lester's experiment where fibrin ceased to coagulate or separate when passed through a tube which had been previously coated with blood-fibrin.

In the case of the natural stone, what has taken place? 1st. Silica has been deposited. 2nd. Coagulation has taken place; and the coagulum has contracted and formed a cavity in its inner surface. 3rd. The addition of more (fluid) silica has taken place; and the external coagulum has been transformed,

passing, after the lapse of time, from the vitreous to the crystallized state.

The second quantity of the fluid silica has coagulated; but it has coagulated in the gelatinous form, squeezing out the remaining water.

This recalls to our minds what takes place in blood-tumours. 1st. Blood is effused. 2nd. The fibrin is coagulated. 3rd. The coagulum contracts and becomes organized into the dense hard fibrous margin. If a second effusion of blood now takes place the blood will remain fluid, and will remain so for a considerable length of time; but at last the fibrin will coagulate squeezing the liquor sanguinis.

To my mind the analogy between the formation of the fibrin in a blood-tumour and the deposition of silicic acid in certain natural stones is complete.

The above considerations of the causes of the coagulation of blood-fibrin may be briefly summed up. 1st. That the coagulation of fibrin is a physical act, and cannot be considered to be in any way identified with a vital property such as the contraction of muscular fibre. 2nd. The coagulation of fibrin depends upon, and is regulated by, the same laws which cause all soluble colloid substances, whether organic or inorganic, to become pectorous. 3rd. That the soluble or fluid form of fibrin ought to be regarded as its allotropic form; and, as in the case of its colloidal analogue, silicic acid, its presence in the blood in the fluid condition depends upon the physical conditions under which fibrin is found in the living body.

GARGET.

During the summer my friend Mr. Power, who was at the time investigating the cause of the epidemic of diphtheria at the north-west of London, told me that he had reason to believe that a particular milk supply was in some way connected with this outbreak, but as far as he had then investigated he could not detect any cause for milk pollution after it left the cow, and that there appeared some *primâ facie* evidence of a milk pollution in the animal itself. The question, therefore, had arisen to him whether there existed any form of disease among cattle which, although capable of fouling milk, produced so little constitutional disturbance in the animal that the disease might escape the notice of dairymen. On inquiry I soon discovered that a condition of milk was known among dairy people as ropy or stringy milk, connected with a state of the udder, in some districts called garget, which did not usually seriously affect the general health of the animal in this condition. On inquiring more fully I found to my surprise that the disease had manifested itself among my own cows on more than one occasion. I afterwards discoverd that at the very time I was engaged in making experiments for my book on milk some of my cows had suffered with the disease, and so little importance did my own bailiff attach to the complaint that he did not think it worth while to call my attention to the subject, or to bring me a sample of the milk, although he was collecting for me in the district the milk of diseased animals. I soon found that veterinary surgeons knew little of the subject, and that most agricultural works and works on veterinary

medicine contained very little information upon the disease, as the cowmen treat the disease themselves, and frequently do not inform their own masters, because they have a belief that the disease comes on from their own ill-treatment or their carelessness in milking of the animals entrusted to their care. My own bailiff has told me that the first intimation that he has had that a cow was affected with garget was by finding upon the strainer sticky or slimy matter, which he had regarded as calling for an overhaul of the herd until he discoverd the affected animal. The milk of one quarter was, he reported, sufficient to spoil the milk of four or five cows for "setting." But if the milk was used for immediate consumption he thought it was very possible that the dairyman might never discover the disease. It therefore became necessary, in investigating the cause of garget, to draw up a set of questions, which I forwarded to friends residing in different parts of England and Wales. The answers to these questions I have condensed in the following statement:

Garget or ropy milk, or cold in udder.

1. Cause of garget?	All observers agreed that cold and wet were predisposing causes; some added fever, over-drinking a blow in full udder, rupture of a vein in stock-making for sale, bad milking, or other causes.
2. Has particular food any tendency to produce the disease?	All but three answered in the negative; one gave change of feed —rye and tares; another grain or beans.
3. Is there more than one kind of garget?	Half the observers answered only one form of true garget; the other half qualified the answer "No," un-

	less cold, injury, and coloured milk be considered as a different form.
4. Is it a frequent occurrence in cows?	Half answered uncommon; the others answered frequent; one stated it was equal to three per cent. per annum of the stock; a few farmers have never had the disease in many years' experience.
5. Does it attack more than one cow in a herd?	All but two answered this question in the negative; two answered "Very rarely."
6. Can a cow have the disease more than once?	Answered for the most part in the affirmative; two or three stated that they always fattened the cows, and therefore could not say.
7. Has the age of a cow any influence on the liability of a cow to attack?	"Young cows," by one observer; the rest negative.
8. What time of year is it most common?	It appears that it is not affected by the time of year; most prevalent however, during cold, wet seasons, and when cows first turned out.
9. Is garget contagious?	All answered that it is not contagious.
10. What are the symptoms of garget?	Tenderness in udder, suppression in quantity of milk, inflammation of udder, milk thick and discoloured; one added, loss of appetite; another, glands in jaw and neck affected, coat harsh and staring.
11. Does it affect the general health of cow?	Some answered "Yes," others "No." One stated it was followed by loss of power on affected side, another, if neglected, gave rise to cancer.
12. How many days does the disease last?	This question was answered variously, from two to six days to two to twelve weeks.

13. Number of quarters, and which commonly affected?	Generally one, sometimes two, rarely all four; hind quarters most prone to the disease.
14. How does it affect the milk during its various stages?	First, thick, discoloured, then bloody, afterwards stringy, becomes ropy, then watery.
15. How soon does it affect the milk?	This question was answered, "At once," except by one observer, who states two or three days, but an unprofessional man would not recognise the disease until shown by the milk.
16. Do the affected quarters dry off?	All agree if disease lasts affected quarter dries off; if taken care of some state milk returns again.
17. Do the affected quarters again yield milk when the cow recovers?	Rarely; usually dry off to next calving; sometimes quarter permanently lost.
18. Is milk from unaffected quarters altered?	One answered "Yes," the rest "No."
If milk from affected quarter is added to other milk:—	
19. Does it affect its keeping?	Yes, it is no good; ought to be thrown away; cannot say milk is thrown away.
20. Does it affect the health of calves fed upon it?	Four answered in the affirmative, four in the negative; those who answered in the affirmative stated that calves became poor and thin, and scoured them.
21. Does it affect its capacity for butter-making?	All agreed it could not be used for butter-making.
22. Does it affect its capacity for cheese-making?	All agreed it could not be used for cheese-making; one stated it separates and goes to the bottom of the vessel; in setting the curd it will not mix.
23. Are the cows kept for rearing calves, butter- or cheese-making, or for a milk business?	Observers kept the cows for butter- and cheese-making, milk business, and rearing of calves.

24. Are the cows kept on high-land or low-land pastures, or are they stall fed ?	Neither high nor low pastures nor stall feed appeared to have any influence on the disease.
25. What breed of cows in the herd ?	Various breeds.
26. Is it ever fatal ?	Sometimes it appears to be fatal, if neglected, by rupture of the udder, or by neglecting to empty the affected quarter during the progress of the disease.

It is obvious, from the above statement, that under the generic name of garget there exists certainly more than one disease.

First. A garget is referred to traumatic origin arising from injury to udder, from blows, poke with horn, lying upon it, rupture of a vein in stock-making (that is, leaving milk in the udder for twenty-four to forty-eight hours, for the purpose of enhancing the value of a cow for sale). I think the largest number of ropy milks arise from his cause. I have reason to think that it is from this cause alone that garget was produced in my own cows, as the complaint only appeared during the time I had a particular cowman in my service and has not again appeared since he left. Calves fed upon the milk of this kind of garget do not appear to be affected in general health. My bailiff has always put the calf to suck the diseased quarter without an ill-effect to the animal.

Secondly. A form of garget produced by cold, which runs an acute course. It does not appear to affect the general health of the animal or the health of pigs or calves which may be fed with the milk.

Thirdly. A form which occurs less frequently, and is possibly of a much more specific nature. This form not only appears to affect the general health of the animal, as in the case of the cow which had loss of power on side of affected quarter, and the cow which had staring coat, loss of appetite, and glands of jaw and neck affected, but it also seems to affect the milk in such a way that it may injure the health of calves, scouring them and causing them to waste away.

The following is the analysis of milk of a cow stated to have ruptured a vein in stock-making. The sample was taken from a cow that had suffered from bloody milk for six weeks.

Milk from affected quarter gives the following :

Total solids	11.97
Fat	2·95
Non-fatty solids	9·02
Ash	0·62

It will be seen that although the milk was distinctly coloured it differed little from normal milk ; no blood-cells could be recognised by examination with the microscope. The light brown or reddish tint of the whey was due to an indefinite particle of brown matter, the nature of which was not made out.

By the kindness of Dr. Jacob I had an opportunity of examining a specimen of milk from a cow that had been attacked by some form or other of garget, which yielded on analysis :

Total solids	11·7 per cent.
Fat	2·5 ,,
Non-fatty solids	9·2 ,,
Ash	0·76 ,,

A very thorough search with the microscope did not reveal anything abnormal, and from the above composition it is evident that this milk would have been passed as good milk by a public analyst. It is important, however, to note that the cow from which the specimen was taken was recovering from the attack, and that an acute stage, in which the milk really had been altered, may have been passed through, before the time that this particular sample was taken from the cow. It is a coincidence of great apparent importance, upon which I leave Dr. Jacob to write, but at the time diphtheria broke out in the Princess Mary Homes at Woking this garget existed in the farm which supplied the Home with milk.

It is hardly necessary for me to point out that the chain of evidence connecting garget with diphtheria is at present incomplete, yet I venture to think that the provable use of diseased milk is a point worthy of considerable attention in the investigation of future outbreaks of diphtheria.

Considering the universal employment of milk as an article of food by all classes of society I have thought it desirable at once to bring under the notice of this Society my researches on garget, because a thorough investigation of milk in disease would, I venture to believe, reveal many facts of importance to the health of the human subject.

It is, however, an investigation that would be surrounded with great difficulties. It would require many observations to be made in different localities under varied circumstances, besides requiring the

expenditure of much time, scientific skill, and money.

A thorough investigation would be far beyond the means of any private individual, perhaps beyond the resources even of our scientific societies, and the subject promises, I think, to be one of sufficient importance to deserve inquiry by Government.

January 7th, 1879.

NOTE.—At the conclusion of the meeting, Dr. Murchison, the president, proposed that a committee, consisting of Sir B. Saunderson, Sir G. Buchanan, Dr. Sydney Coupland, and Mr. Smee, should be formed to further investigate the udder disease of cows. It was soon discovered that for a report on this subject to be of any value would require the expenditure of at least £1,000, and as this sum could not be obtained either from the Society or the Government, the work of the committee was reluctantly abandoned. During the sittings of the committee a communication was received from Lübeck, which clearly showed that tubercular disease was prevalent among the stall-fed cows. Dr. Klein in 1882 reported his experiments upon udder disease of cows suffering from scarlatina and diphtheria, and in 1895 a Royal Commission on Tuberculosis in Cattle was appointed.

The Detection of Germs & Organic Matters in the Atmosphere.

The detection of germs and minute quantities of organic matter in the atmosphere has always been attended with considerable difficulty. I propose in the following paper to bring under the notice of the Chemical Society a method which I have devised, by which I believe the detection and determination of ammonia and other volatile organic impurities existing in the atmosphere will be greatly facilitated. From the simple construction of the apparatus very little description is necesary. The apparatus consists simply of a glass funnel drawn out to a point and closed at the extremity. The funnel is supported in an ordinary stand and filled with ice (I find an eight or nine inch funnel the most convenient size). Condensation of the aqueous vapour of the atmosphere then takes place, and accumulates in the form of dew upon the outside of the glass funnel, where the moisture runs together into drops, and trickles down the side of the vessel, finally dropping from the point into a small receiver.

The name which I propose to give this method of collecting volatile substances for analysis is "Distillation by cold." By this apparatus many substances which are decomposed at high temperature may be distilled. Thus many delicate odours of flowers may be distilled, the distillate in most cases will not keep more than three or four days, when it is apt to become sour and apparently undergoes an acid fermentation. The method I adopted for distilling the odour from flowers was to place them under a bell glass sufficiently large to cover the funnel containing the ice. I found that when a little œther was placed in a dish to

evaporate under the bell glass at the time the distillation was taking place, the odour from the flowers was completely abstracted, and the flowers became scentless; nevertheless, after a few hours, the flowers had formed a second quantity of scent which might again be removed—thus proving that the scent forming organs of flowers was situated in the flower itself.

The fluids condensed, containing the odour of the flowers have been subjected to the action of various re-agents, and the results have been thrown into a tabular form for the sake of comparison.

Flower.	Nessler Test.	Nitrate of Silver.	Baryter Water.	Permangate Minims.
Pink (white) ..	Clear orange colour	Copious precipitate	Slightly turbid	24 minims required for complete.
Honeysuckle ..	Orange	Blackish precipitate	White precipitate	8.
Tobacco, burnt with Spirits of Wine	Muddy yellow precipitate	Black precipitate	Clear	41.
Stocks	Orange precipitate	Clear	Slightly turbid	Not taken.
Pink (red) ..	Clear orange	Clear	Precipitate	47.
Lily	Clear yellow	Black precipitate	Precipitate	38.
Tuber Auratum..	Clear yellow	Black precipitate	——	82.
White Lily ..	Yellow precipitate	Trace of reddish precipitate	Clear	Not taken.

For the present I have limited my investigations to the detection of organic volatile matter present in the atmosphere. 1st. I have ascertained the quantity of

ammonia contained in the distillate, and in every analysis the amount of ammonia has been estimated by the Nessler test. The condensed fluids were separately analysed on several occasions by the different methods of applying the Nessler test, that is to say, the fluids were subjected to the dual action of the Nessler test, they were also distilled with carbonate of soda, and lastly were distilled with carbonate of soda and permangate of potash. In no case however was the quantity of ammonia increased by these two latter methods, consequently in all the experiments the quantity of ammonia has been delivered by the direct action of the Nessler test, 2nd. I have examined the state of the organic matter by adding a few drops of the condensed fluids to grape sugar and exposing them in closed tubes to a temperature of 80° to 90° F. for twenty-four hours in order to promote fermentation if any ferment was present. I may here state that in all the fluids distilled from the atmosphere no fermentation had taken place, except on one occasion the fluid condensed just before a thunder-storm appeared to set up fermentation, although in one or two cases of fluids containing the odour of flowers a slight action appeared to have taken place.

I have examined under the microscope the appearance of stains left on glass slides from the condensed fluids. I found the stains to contain crystals of various forms, the form apparently depending upon the source from whence the fluid was deposited. At present, however, I have not made a sufficient number of observations of crystals formed from these fluids to be

able to decide from the appearance of the crystaline stain, from what source the stain was derived, although I have observed that fluids collected from similar sources apparently left a stain having definite and more or less characteristic crystals. The character of the crystals thus formed are definite enough to justify a hope that hereafter it may be possible to distinguish a scarlatina atmosphere from erysipelas, &c.

I have observed that not only do these deposited fluids crystalize in various forms but the same fluid will in some cases by keeping a few days, so alter its constitution that it will crystallize in another form, consequently it is advisable to mount the stains from fluids as recently condensed as possible. Again I have noticed that the crystals formed in the first instance from some fluids deliqueces and crystalize in other forms on again drying the slide over sulphuric acid. This change in the form of the crystals I have noticed more frequently take place in the stains derived from fluids collected in wards containing zymotic diseases. In fluids containing the odour of flowers I have noticed portions of the crystals will recrystalize on the covering glass of the slide, as if the odour depended upon a substance analogous to camphor, this was more especially the case with the honeysuckle. I have constructed tables to shew the total quantity of fluid condensed from various situations on the same day, and collected during the same number of hours, and also the results obtained from the same situation over a series of days.

It will be noticed that the quantity of organic

ammonia contained in these condensed fluids, even where the distillation has been carried on in a very pure atmosphere, is vastly higher than the amount of ammonia found in ordinary potable water derived from the chalk springs. Is it not possible that the ammonia and the nitrates existing in the chalk streams have their origin in the condensation of atmospheric impurities? The mean analysis of four distillates (from the chalk district of) Carshalton gives ·4436 grains of ammonia per gallon. The analysis of a week's rain-fall from the same district gave ·2298 grains of ammonia per gallon. The water from a chalk spring gave ·2330 grains of nitrogen, consequently an increase in the quantity of nitrogen on waters derived from chalk springs might be expected from a sudden rain-fall, after a draught carrying down the impurities of the atmosphere. It is curious that in a fernhouse where natural distillation is carried on and the watery vapour is distilled over and over again, and where the plants might have been expected to have absorbed every trace of ammonia, nevertheless ·3942 grains and ·0942 grains per gallon were shewn to be present by the Nessler test.

The following interesting facts will be noticed that the quantity of ammonia calculated as grains per gallon has no relation to the absolute amount of distillate formed :—

		Amount of Ammonia per gallon.	Minims.
Thus the distillate amounted to 120 minims on the following days, but the quantity of ammonia per gallon was	April 16th—	·1971	120
	,, 17th—	·2956	,,
	,, 18th—	·8870	,,

		Amount of Ammonia per gallon.		Minims.
	April 25th—	·8085		120
	May 8th—	1·0841		,,
Again on	,, 13th—	·3942	Garden.	600
	,, 14th—	·5913		,,
	,, 16th—	·9856	Stables.	,,
	,, 23rd—	3·9424		,,

It will be observed that with an equal amount of condensed fluid the amount of ammonia varied considerably.

From observations made on fluids collected from various sources on the same day, not only did the quantity of the condensed fluid vary but also the per centage of ammonia in that fluid. The funnels used were of uniform size and exposed during the same hours to the action of the atmosphere, on April 23rd.

Source.	Minims.	Ammonia.
An Erysipelas Ward	100 ..	2·3654
In Garden (London)	140 ..	·8439
A Scarlatina Ward..	86 ..	1·0996
Phthisis Ward	80 ..	1·4784

The wards in which these experiments were carried out were ventilated by hot air and have been constructed with all the most modern improvements for ventilation, nevertheless it will be observed that the quantity of ammonia is in considerable excess of that in the ordinary London atmosphere, whilst in wards ventilated by open windows the increase is very trifling.

By this method of analyzing air a very slight variation in the quantity of organic matter in the atmosphere may be detected. In illustration of this point on April 16th, some drains in our house were discovered to be out of order and it was found necessary to have them opened in the area at the back of the

house. Whilst the drains were open I placed one of the funnels in the area, and another in the yard, about twenty yards off. I found that the air in the area distilled down fifty-five minims of fluid containing ammonia equal to 6·8807 grains per gallon, whilst I found 120 minims of fluid in the garden from another funnel yielding only 0·1971 grains per gallon; consequently the distillate from the area contains thirty-five times more ammonia than the distillate from the garden.

Again on May 2nd, I tried whether the height of atmosphere had any effect on the quantity of distillate formed. For this purpose I placed two funnels at different heights in my stables, the experiment was carried on at night when all the ventilators had been closed. On the floor of the stable I placed one funnel, where I obtained 420 minims, containing ammonia equal to 2·9568 grains per gallon. The other funnel I placed in the loft by the side of the ventilating shaft, the amount of fluid collected there was 540, containing ammonia equal to 3·5440 per gallon. This experiment was again repeated, when the quantity of fluid condensed in the loft amounted to 600 minims against 540 on the floor of the stables, yielding in both cases 3·9424 grains of ammonia per gallon. The fluid condensed from a funnel placed on the third floor balcony of St. Thomas's Hospital (height about sixty feet), has been compared with that collected from a funnel placed on the ground at St. Thomas's but protected from the rain, and also with the garden of 7, Finsbury Circus; the following is the result:—

Minims collected.	Ammonia, grains per gallon.	Date		
240 ..	·9856 ..	May	24—5	3rd floor, ground } St. Thomas's.
240 ..	·9856 ..	,,	24—5	
240 ..	·7884 ..	,,	——	7, Finsbury Circus.
150 ..	·9856 ..	,,	25—6	3rd floor, ground } St. Thomas's.
270 ..	·6899 ..	,,	25—6	
360 ..	·5769 ..	,,	25—6	7, Finsbury Circus.

I thought it would be interesting to note if the flood and ebb tide had any influence on the quantity of ammonia existing in the atmosphere. This experiment was carried on in close proximity to the river. The following is the results of the observations :—

	EBB TIDE.			FLOOD TIDE.	
	Wind.	Minims.	Ammonia, grains per gallon.	Minims.	Ammonia, grains per gallon.
May 17th ..	N.E. ..	190 ..	·6899	90 ..	.6563
,, 18th ..	N. by E. ..	28 ..	·4219	30 ..	·7884
,, 19th ..	S.S.E. by S.W... (22 London).	None. ..	——	None. ..	——

The Registrar General in his weekly reports calls attention to a remarkable fog which hung over London, Monday, April 30th, 1872, I find that the distillate from my apparatus, which happened to be exposed at the time, contained only seventeen minims of fluid which yielded ammonia equivalent to 4·1734 grains per gallon.

I have noticed this curious fact that the amount of fluid distilled from the air, appears to bear no relation to the amount of evaporation by Smee's evaporonometer. Nor does Smee's evaporonometer agree with the difference between the dry and wet bulb thermometers.

On some days I have noticed that very little moisture, in some cases none has been condensed, this is probably due either to the excessive dryness of the atmosphere or to the temperature being very near the

freezing point. On these days, I propose saturating the atmosphere in the neighbourhood of the funnels by steam, and then condensing it together with the ammonia, &c., which it may hold in solution. The plan I have adopted for this experiment, is to have a small vessel three feet by three feet by three inches deep, which I fill with distilled water and heat with a gas jet. The funnel is placed in a position so that the air is wafted by the wind over the pool from which steam is generating on to the funnel, where the moisture is condensed and trickles down into the receiver, care of course must be taken that the products of combustion from the gas jet do not come in contact with the apparatus. I have several times observed on shaking up the distilled fluid with an acidulated solution of permanganate of potash, the permanganate has rapidly been discoloured, showing that organic matter in an unoxydised state was present. The quantity of cubic centimetres of the permanganate solution required from the oxidation of the organic matter is given in the annexed table, and for the sake of comparison the number of grains of ammonia per gallon, estimated by the Nessler test has likewise been tabulated. A cubic centimetre of the permanganate solution is equivalent to eight-hundredths of a milligramme of active oxygen.

Carbonic hydrochloric sulphurous and sulphuric acids have been detected in the condensed fluids, but they have not been quantatively determined.

For the present my investigations have been limited to the amount of nitrogenized matter existing as ammonia in the atmosphere. I have observed on days

when the greatest amount of ammonia was detected, the electric currents were either very feeble or totally absent. In many cases spores of fungi have been detected in the stain left in the microscope slide by the evaporation of the distillate. In a few cases fungoid growths have been developed in these fluids after this had been allowed to stand two or three days, further observations however are required upon this interesting phenomena.

No.	Total cubic centimetres of permanganate discoloured per gallon of distillate.	Ammonia, grains per gallon Nessler test.	Source.	Date.
14	204·1	·3942	Fernhouse	April 20th
31	84·4	·4928	Garden	,, 27th
51	233 3	·6899	Garden	May 7—8
52	116·6	·3942	Rain, London	,, 7—8
55	495·8	1·0841	Garden and Hcl.	,, 9—10
62	194·4	·3942	Garden	,, 12—13
66	279·9	·5913	Garden	,, 13—14
70	216·5	·9856	Garden	,, 16—17
71	302·8	·7884	Garden	,, 17—18
89	99 9	3·9424	Floor of stable	,, 23—24
90	262·5	3·9424	Loft of stable	,, 23—24
101	311·0	·6899	St. Thomas's Hospital grounds	,, 25—26
105	291·8	·8869	Garden	,, 26—27
—	87·5	——	New River water	——

I am indebted to Dr. Evans, of St. Thomas's, and Mr. Franklin, of Victoria Park Hospitals, who kindly undertook the charge of the apparatus at those institutions, in order that observations might then be made simultaneously with those I was carrying on at Finsbury Circus.

THE AIR WE BREATHE,

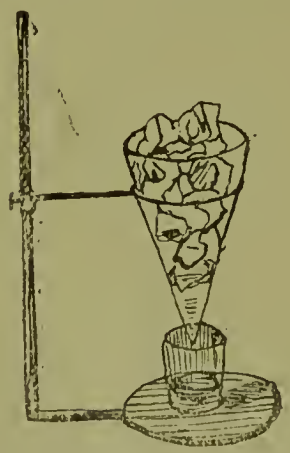
BY

A. H. SMEE, F.S.S., F.C.S.

[*Extract from* Transactions of the National Association for the Promotion of Social Science, *edited by C. W. Byalls.* Norwich Meeting, 1873.]

The atmosphere has been considered to be a mixture of oxygen, nitrogen, with a small quantity of carbonic acid, and chemists have been content for many years to rest upon that knowledge, and have not sought for those more recondite matters which are supposed to lead to disease.

It appeared to me desirable to ascertain what class of compounds existed in the atmosphere, besides the gases of which it was known to be composed, and the watery vapour which also invariably exists in varying amount. For the purpose of experiment, I resorted to the process of depositing aqueous vapour by ice, by which a liquid containing various products was deposited. On subjecting this fluid to examination determinate results have been obtained which promise a rich harvest on future examination. The apparatus employed for the deposit of the fluid from the atmosphere was simply a glass funnel drawn to a point. When in operation, ice broken up to pieces about an inch across is placed in its interior, when moisture is deposited on the outside and runs to any convenient vessel placed below to receive it. The deposited liquid when dried over sulphuric acid on a microscopic slide, deposits remarkable crystals. Liquids containing the odour of flowers on evaporation deposit camphor-like bodies which crystallize and re-crystallize. The delicate odour of the pink, the delicious perfume of the honeysuckle, may



be obtained in the aqueous deposit in reasonable quantities. Many of these scents will not keep any length of time, as they become sour in a few days, but the addition of pure alcohol prevents that change. These perfumes may be taken as a type of a class of substances which exist in the atmosphere.

The more important compounds, however, which may always be found to a greater or less amount are nitrogenous substances, which may possibly have an important influence on all living beings. It may be stated broadly that the deposited water containing the nitrogenized compounds from the air contains a much larger quantity of nitrogen in combination than that in the nitrates usually existing in chalk water, and as the source of the nitrogen has been an object of solicitude to the chemist when it is found in potable waters, surely the presence of a larger amount of nitrogen in organic compounds existing in the atmosphere demands the most continuous and minute investigation.

The nitrogenized organic compounds in the atmosphere vary in amount, according to the day and to the situation in which the water containing them is deposited. When the fluid containing these nitrogenized bodies is dried over sulphuric acid definite crystals are formed which have curious properties. Some of these crystals deliquesce after formation, and re-crystallize under other forms. This singular property is noticed particularly in crystals from fluids deposited in the wards of hospitals where zymotic diseases exist.

Here is a field promising important results when carefully cultivated on a large scale, for who knows

whether we may not ultimately discover the poison of a cholera, a typhoid, a scarlet fever, an erysipelas or other disease by the form of crystal which is deposited from the atmosphere. In these crystals the individuality, or, speaking more strictly, scientifically, the peculiarity or special character of the nitrogenous compound appears to exist. The quantity of water which is reduced from the atmosphere by the apparatus varies materially at different times, and sometimes none is yielded, as the air appears to take it up as fast as it is deposited. The amount of nitrogenized compounds found in the deposited fluid has no relation to the quantity of water deposited, to the difference between the dry and wet bulb thermometers, to the amount of evaporation shown by the evaporometer, an instrument described in my father's work, "My Garden."

In the atmosphere of Carshalton an amount of nitrogen in combination equal to that in ·4436 grains of ammonia per gallon was found, whilst in the rain-fall of the same district the amount of nitrogen in combination was equal to that contained in ·2298 of ammonia, whilst the water of the chalk springs yielded nitrogen equal to that in ·2230 grains of ammonia per gallon. In equal amounts of deposited water the amount of nitrogenized substance varies considerably; for instance, in five cases where the deposit was 120 minims the amount of nitrogen in ·1971, ·2956, ·8088, ·8870 respectively. In two cases where the deposited water amounted to 600, the nitrogen in combination amounted to that contained in ·3942 and ·5913 grains of ammonia in a gallon, and in my stables, where from the circumstances we may

expect considerable variation, the nitrogen amounted to that in ·9856 and 3·9424 respectively, although the amount of deposits in both cases was equal for the same time. The comparison between the amount of nitrogenized compounds on the same day and for the same time, under varying circumstances, yields instructive results, thus: On April 23rd, 1872, the amount of nitrogen from 140 minims deposited in our garden in London was equal to that contained in ·8439 of ammonia. From 100 drops deposited in an erysipelas ward, it was equal to that contained in 2·3654 grains of ammonia. From eighty-six drops deposited in a scarlatina ward, it equalled to that in 1·0996. From that in a phthisis ward to that in 1·4784 of ammonia per gallon. In those cases where a great difference of amount of nitrogenized compounds was found, the wards were under a system of artificial heating and ventilation. When wards were ventilated by simply opening the windows the variation was much less marked or disappeared, an experience which opens up for further investigation and consideration the whole theory and practice of ventilation.

The diffusive power of the atmosphere was well demonstrated on one occasion when the drains of our house required repair, as the organic nitrogen near the drain amounted to that contained in 6·8807 of ammonia, thirty-five times more than that yielded from the air in the garden about twenty yards distant. The relative power of diffusion at different times, at different temperatures, and at different barometric pressures, raises questions arising out of these investigations worthy of long continued and careful study. Physical

conditions of atmosphere affect the quantity of nitrogen in organic combination. On April 30th, 1872, a curious irregular mist passed over some parts of London, which was specially recorded in the weekly returns of the Registrar-General. My apparatus was at work in the London garden when the mist passed over, when drops were deposited which yielded nitrogen in combination equal to that in ammonia amounting to no less than 4·1734 grains per gallon.

It has been noticed that when epidemics have raged mists have frequently been a concomitant. It was observed in one cholera epidemic that London was never seen from Greenwich Hill whilst cholera lasted, so that this mist experiment opens a field for investigation of pressing urgency now that cholera threatens, and which demands careful and repeated observations. The organic matters contained in the atmosphere are not in the state of the highest oxydation, and require a varying quantity of permanganate of potash effectively to oxydise them in different cases. The relative proportion in thirteen instances varied from 84·4 to 495·8 grains for every gallon of deposited fluid, whilst the water supplied by the new River Company took 87·5 per gallon to effect the complete oxydation of its organic matter. Nothing can prove more demonstratively the immediate necessity of studying the atmosphere when the sources of danger are so much greater in the air than in a potable water. Small quantities of carbonic, hydrochloric, sulphurous, and sulphuric acids have been detected in the deposited fluid from the atmosphere. Mycelia of fungi have been sometimes seen in the deposited water after a few days,

and occasionally, but not always, slight fermentation has taken place when the deposited fluid has been added to a solution of grape sugar.

Having pointed out some of the leading results of my investigation of the foreign substances in the atmosphere, I venture strongly to recommend that the examination of the air should henceforth be made by authority in a systematic manner. For these researches to be of real and continuous benefit a laboratory should be appropriated to this special object, where two or three competent persons should be continually employed in the analysis of the deposited water. No individual is competent to carry out these operations on an extensive scale single-handed, and therefore I must now leave the subject in the hands of our sanitary authorities, having made a case for the prosecution of the investigations.

Should the Congress consider the subject to be important, and to promise good practical results, I would ask that they should recommend our Government to take the necessary steps to give us a daily return of the constituents of the atmosphere, for surely the "air we breathe" is as worthy of study as the "water we drink."

THE CHEMICAL COMPOSITION OF ORCHIDS.

The Grange,
Carshalton,
10/6/97.

Dear Mr. Veitch,—

I have put together a few observations on the chemical composition of the Cattleya, together with some suggestions as to its food requirements, which I trust may be of some interest to yourself and to the members of the Orchid Committee.

In the *Gardeners' Chronicle* of February, 1894, there was an article on the chemical composition of Cattleya Labiata, and also giving the analyses of rain-water in temperate and tropic climates, which showed a large increase in the amount of nitric acid in the rainfall of the tropics compared with temperate zones.

Country.	Authority.	Milligrammes.
Liebfrauenberg (Alasce), France ...	Boussingault	0·18
Rothamsted, England	Lawes & Gilbert	0·42
Java	Homans	2·30
Isle of Réunion	Raimbault	2·65

This is as may be expected, for it is well known that thunder rain contains nitric acid, derived from the rapid oxidation of the nitrogen of the atmosphere by the electric discharge, combining immediately with the pure ammonia in the atmosphere, forming ammonia nitrate.

In connection with this subject it is well to take into account the chief constituents of the air.

Professor Frankland published in the Journal of the Chemical Society (vol. xiii.) the results of analysis

of the composition of airs from various sources, which demonstrated that the composition of the atmosphere exhibits certain fluctuations, confined, however, within very narrow limits.

The air near the sea contains about the same proportion of carbonic acid as that resting over land. The sea air was richer both in carbonic acid and oxygen by day than by night.

	Average by Sea.		New Granada.	Bogota.	
	Day.	Night.		Dry Season.	Rainy Season.
Nitrogen ...	78·886	79·006	79·946	78·932	78·966
Oxygen	21·060	20·961	21·014	21·022	20·996
Carbonic Acid ...	·054	·033	·040	·046	·038
	100·000	100·000	100·000	100·000	100·000

	Chamonix, 3,000 feet.	At the Grand Mulets, 11,000 feet.	Mount Blanc, 15,732 feet.
Nitrogen	79·086	79·087	78·989
Oxygen	20·881	20·802	20·950
Carbonic Acid... ...	·063	·111	·061
	100·000	100·000	100·000

The Carbonic Acid in the atmosphere appears to increase with altitude to attain its maximum at 11,000 feet, and then again diminishes in quantities above that height.

In the neighbourhood of our large towns the atmosphere is injuriously affected by the products of

the combustion of coal, in the form of sulphurous and sulphuric acid and ammonia, and in some places—for instance, the Tyne and Clyde—by chlorine given off from the chemical works. There is also given off some of the more volatile petroleum oils, which form a greasy slime, which in fogs is deposited on the glass of our plant-houses, and falling upon the leaves of the plants, interferes with their power of osmosis and exosmosis so necessary for their well-being.

I have myself noticed that the quantity of ammonia in the atmosphere was subject to considerable variation; the greatest amount was detected on days when the electric currents were feeble or totally absent. I have also observed that the amount of oxidisable matter present in the atmosphere had no relation to the quantity of ammonia present.

I think it is probable that the relation of ammonia to carbonic acid has a considerable influence upon the growth of epiphytal orchids. This is the probable cause that many orchids—such as Oncidium Varicosum on the one hand, and Phælenopsis on the other—cannot be kept in vigour for any length of time in this country.

The analysis of old and new pseudobulbs shows that there is less mineral matter in old bulbs when compared with new. Apparently these plants have great difficulty in obtaining the earthy salts, and are, therefore, obliged to withdraw from the old bulbs some portion of their earthly constituents. We know that allowing the flowers to remain on the plants until they have withered is followed by the shrivelling of the pseudobulb and with the exhaustion of the plant; the

better the variety the more delicate the constitution of the plant and the greater the exhaustion caused by flowering.

	Old Pseudobulbs.	New Pseudobulbs.
Dry substance, per cent. ...	9·12	8·07
Nitrogen, per cent.	1·21	1·14
Mineral matter (ash), per cent.	0·41	0·63
Constituents of the ash in 100 parts.		
Potash carbonate	29·90	30·69
Lime carbonate	52·02	35·23
Magnesia carbonate	12·05	14·47
Lime phosphate	3·42	10·68
Iron oxide	0·16	0·17
Silica	2·42	8·77

It occurred to me that it would be desirable to find out which, if any, of the earthy constituents were removed from the pseudobulb by the flowers. For this purpose I sent up to my friend, Prof. Ogston, a large number of fresh-cut blooms of the largest and best varieties in my collection of Mendelii, Mossiæ, and Purpurata.

The analysis of the fresh-cut Cattleya flowers gave :

Water	84·27
Vegetable substance	13·72
Ash soluble	1·18
Ash insoluble	0·83
	100·00

	The percentage composition of fresh cut flower.	Percentage composition of dried flower.	Percentage composition of the incinerated ash.
Water	84·270	nil.	nil.
Organic matter ...	13·720	87·21	nil.
Phosphoric acid ...	·058	·39	3·10
Potash	·634	3·19	25·00
Lime	·348	1·84	14·40
Magnesia	·120	·60	4·71
Sulphuric acid ...	·034	·17	1·35
Silica	·164	·57	4·50
Carbonic acid, iron, soda, alumina ...	·702	6·03	46·94
	100·000	100·00	100·00

The carbonic acid in the ash was originally present in the bloom as organic compounds (nitro-hydrocarbons) combined with the potash, lime and magnesia.

I do not, at present, see in what manner the epiphytal species in their native habitats obtain the alkaline and earthy salts, especially the silica, which is not easily soluble, and does not exist in a soluble condition to any large extent in any soil.

I may mention in passing that chlorophyll ($C_9H_9NO_4$) is the green colouring matter of plants. Ammonia and nitric acid salts appear to promote the combination of nitrogen with the hydrocarbons in the formation of this substance, but the absence of or the exposure of plants to an excess of sun-light seems to interfere with its formation. It may be that under these conditions another product, with a formula of $C_{19}H_{20}NO_5$ is formed.

Cyanine and Xantheine, the colouring material of flowers, are closely allied to Chlorophyll.

Cyanine is found in red and blue flowers; in the former the juice is acid, in the latter neutral. Blue flowers may change to red, but never become yellow, and they fade away until their colour disappears.

Xanthine, the yellow material of flowers, is insoluble in water. Yellow flowers as they wither never become blue or red. Neither of these substances have at present been obtained in their pure state, but a deduction of their chemical composition may be inferred from blue indigo ($C_{16}H_5NO_2$) compared with white indigo, which has a formula of $C_{16}H_6NO_2$.

Comparing the analysis of the blooms with the composition of old and new pseudobulbs, it is evident that a large amount of the mineral constituents of the pseudobulb are abstracted by the flower. The question cultivators have to consider is, in what manner can these plants recuperate by the re-absorbtion of these mineral constituents into their organisms, for it is evident, if they are not furnished with a means of obtaining a fresh supply, they will continually withdraw these substances from their old pseudobulbs, with a result, impoverished growth, smaller and smaller in size, poorer blooms, and ultimate death.

I therefore thought that it would be well to experiment upon an old and starved variety of Trianœi. I fed this plant once a week, during the growing season, with 2 or 3 ounces of water, which contained nitrate of potash, nitrate of ammonia, phosphate of ammonia, and carbonate of magnesia, of the strength of $\frac{1}{2}$ an ounce

of nitrate of potash and ½ an ounce of nitrate of ammonia, with a small quantity of the other salts, with the result that the plant made stronger growth, produced a greater number of flowers, which were brighter in colour. In 1895 I tried a larger number of plants, and I was so satisfied with the result, that in 1896 I added nitrate of potash and nitrate of ammonia each week during the summer to the rain-water tanks of the Cattleya house. The total quantity used during the summer was 1lb. of the nitrate of ammonia and 1lb. of the nitrate of potash. This worked out at the rate of 2·5 grains per gallon. Many of the flowers of the Cattleya which were shown at the Drill Hall on May 9th this year were larger, brighter, and had more substance than in previous years.

This year I intend to increase the amount to 5 grains per gallon during the summer, that is to say, from May to September. I also propose to treat some of the plants with small quantities of phosphate of ammonia and carbonate of magnesia, in addition to the nitrate of ammonia and potash. I expect that I shall be able to make a favourable report on a future occasion on the results of these experiments.

I suspect further observations will prove that the assimilation of phosphates by plants sets free the phosphorous, which, combining with the nitro hydrocarbons of the tissues, will tend to promote inflorescence, and will probably increase the germinating power of the seed of epiphytal orchids.

I am, yours faithfully,

A. H. SMEE.

THE CHEMICAL PROCESSES WHICH TAKE PLACE IN THE ORCHID DURING GROWTH.

The Grange,
Carshalton.

July 7th, 1897.

Dear Mr. Veitch,—

At your suggestion I have jotted down some few remarks to further elucidate what I believe are the chemical processes which take place in the orchid.

Orchids take up through their leaves carbonic acid, free ammonia, and water in the form of watery vapour, but I believe the alkalies and earthy salts are taken up through the roots. I consider that chlorophyll is built up on an ammonia type. Ammonia (NH_3) may be regarded as $N\begin{cases}H\\H\\H\end{cases}$ but in the case of the tertiary nitrides, each equivalent of the hydrogen may be replaced by an organic radical (C_nH_{n+1}). If the radical methyll C_2H_3 (the alcohol of which, $C_2H_4O_2$, is wood spirit, derived from the destructive distillation of wood) replaces each of the equivalents of hydrogen, we get a substance with the formula $N\begin{cases}C_2H_3\\C_2H_3\\C_2H_3\end{cases}$; if three equivalents of carbonic acid 3 (CO_2) are then absorbed, a product would be the result with the formula $NC_9H_9O_6$, which, under light, gives up two equivalents of oxygen; chlorophyll is formed $C_9H_9NO_4$, and 2 equivalents of oxygen is given off. It is a well-known fact that plants differ from animals by absorbing carbonic acid, and giving off through their leaves oxygen. This is just the reverse process to that which takes place in the animal economy.

I have found that by making an infusion of ordinary meadow grass, by pounding it up in fifteen times its weight of water, filtering the fluid, examining it as in water analysis, and comparing an infusion from the same quantity of grass which had recently been irrigated with sewage, the yield of

	In Meadow Grass.	In Sewage-Fed Grass.
Nitrogen as ammoniacal salts was	2·8	8·4
Organic matter	0·7	1.4
Albuminoid ammonia	5·6	12·6
	9·1	22·6

I also observed that the quantity of free ammonia and albuminoid ammonia in the sewage grass after two or three weeks growth diminished in quantity, and more closely corresponded with the ordinary meadow grass, proving that the ammoniacal salts had become absorbed and converted in the tissues of the grass. Watercress grown in the effluent from a sewage farm contained more free and albuminoid ammonia than watercress grown in spring water.

I think it is probable that when the plant has nearly finished its growth it is the period when the mineral salts are taken up through the roots, and that two equivalents of chlorophyll $\begin{cases} C_9H_9NO_4 \\ C_9H_9NO_4 \end{cases}$ take up an equivalent of carbonate of lime, C_aOCO_2, which is decomposed by some process which is not quite clear into $C_{19}H_{18}NO_5 + C_aO\ NO_5$ nitrate of lime; this is stored up in the pseudobulb. It is probable that many of the orchids which grow in their native habitats derive their

earthy salts from the bark of the trees on which they grow by a process of dialysing the earthy salts from the tree and absorbing them through the root of the orchid.

It is well known that crystalizable salts mixed with gelatine, gum, or other colloidal substance placed on a membrane upon water, the salts will dialize, that is, pass freely through the membrane into the water, whilst the colloids will remain behind on the membrane.

From the researches of Hornberger it has been shown that if the increased growth of trees when thinned is due to the effect of light on the soil, resulting in the more rapid decomposition of the humus, rather than to the direct action of the light on the crowns of the trees, the wood of trees which have been thinned should be richer in ash constituents and nitrogen than that of trees which have not been thinned. It has frequently been shown that the outer wood is richer in minerals than the inner wood. He compared the composition of (1) the outer, (2) the intermediate, and (3) the inner wood of two beech trees over 100 years old, one of which (A) had, for 13 years, the advantage of increased light, the other (B) not. The numbers show the average results per thousand in the dry wood :—

		KO.	CaO.	MgO.	Mn_2O_3.	PO_5.	SO_3.	Total.
A	Inner wood	2·25	1·23	0·33	0·24	0·38	0·15	4·58
	Intermediate ,,	1·94	1·50	0 47	0·33	0·24	0·21	4·69
	Outer ,,	1·51	1·59	0·48	0·33	0·28	0 20	4·39
B	Inner ,,	1·09	1·28	0·46	0·24	0·23	0·15	3 45
	Intermediate ,,	2·33	1·03	0·35	0·17	0·42	–	4·35
	Outer ,,	1·35	0·84	0·21	0·15	0·27	0·23	3·05

Comparing the outer wood of the two trees, there is a greater amount of each constituent, except phosphoric and sulphuric acids, in A than in B. When the amounts of ash constituents of the outer wood are divided by the

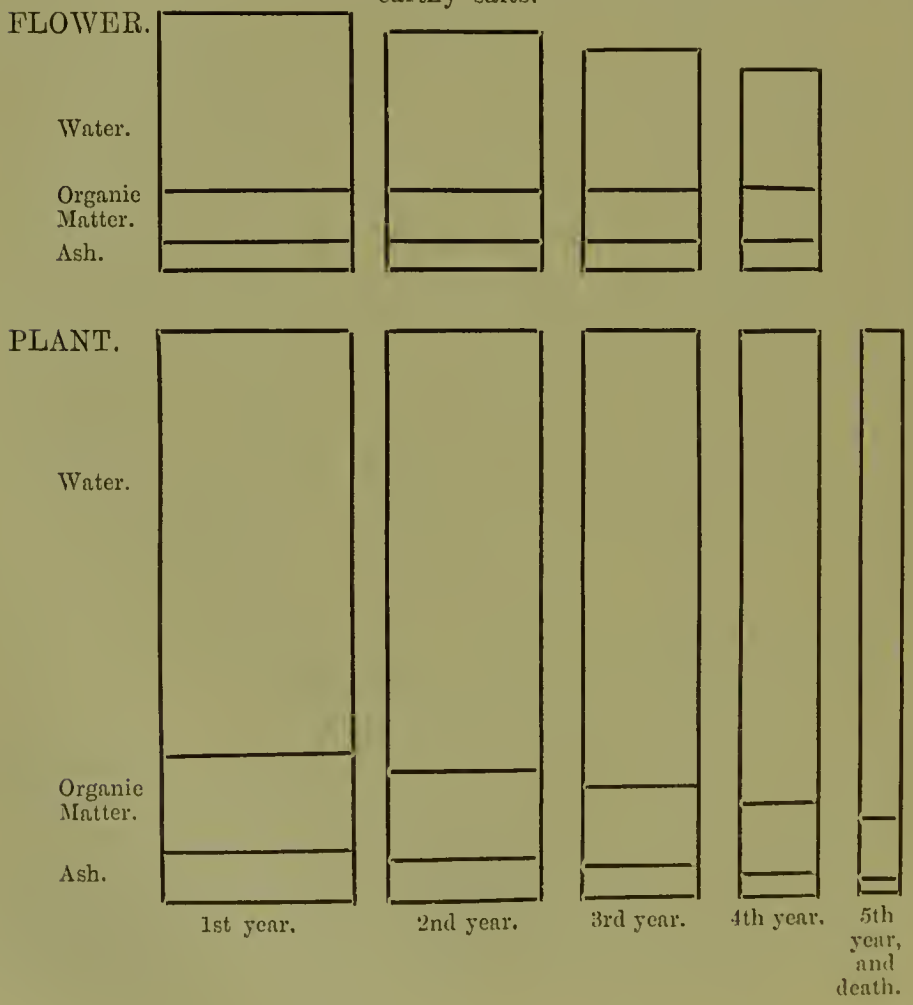
corresponding arithmetical means of those of the intermediate and inner wood, the quotients for A, except in the case of potash, are greater than in B. The difference is still more distinct if the outer and intermediate wood alone are considered. Under the influence of increased light there was thus a greater percentage of mineral matter in the wood, notwithstanding that the production of wood was increased. There was also an increase in the amount of nitrogenous matter.

This would be an explanation of the manner epiphytal orchids derive their earthy and alkaline constituents, and it is suggestive of the cause why orchids growing on native wood go wrong when the wood begins to decay. The earthy salts would then be in a different state, and would be probably less soluble, and therefore in a condition which the root of an orchid cannot absorb. I have found that hanging an epidendrum ciliare up and simply watering, although it flowered for the first year or two, ultimately perished, no doubt due to exhaustion caused by the removal of a certain proportion of the earthy salts by the flowers, and by the inability of the plant to obtain a fresh supply of the earthy salts. Dendrobium nobile will also exist for a year or two under similar conditions, but will gradually decrease in the size of its growth and ultimately perish.

I noticed that after a severe thunderstorm on Whit-Sunday, the tips of the leaves of the bull-rush became changed from their green colour to the brown colour of autumn ; this was no doubt due to a rapid formation of ozone during the storm, acting upon the chlorophyll and bleaching it. I have found that a similar re-action takes

place by placing a portion of the leaf of the bull-rush in per-oxide of hydrogen, HO_2, and exposing it to sunlight. The influence of sunlight and a temperature over 70 F decomposes the HO_2, and sets free an equivalent of oxygen O, which attacks the chlorophyll with the result, bleaching and turning brown of the edges of the leaf.

Diagram to illustrate the effect of removal of earthy salts by the flower of an orchid deprived of the possibility of getting any fresh earthy salts.



Turning now to the flower bud when it first appears from the sheaf, it is green from the chlorophyll, but as it expands it becomes white by the rapid oxidation of the chlorophyll. Carbonic acid and water are formed, and the colouring matter is probably in the condition of white indigo, but after a few days a further equivalent of hydrogen gets oxidized, and the mauve colour of the cattleya appears. I have no doubt that many of the white blooms which become tinged with colour, and are therefore comparatively valueless, derive their colour in the above manner, and it is only the plants of weak constitution are the true ablinos.

The act of the expansion of the flower is a reversal of the process of the growth of the leaf. In the case of leaf carbonic acid is absorbed by the tissues, and oxygen expired; in the case of the flower carbonic acid is expired and oxygen absorbed.

Assuming that the chlorophyll in the flower bud has the formula $C_{19}H_{18}NO_5$ by the absorbtion of fifteen equivalents of oxygen, a compound would be formed with the formula $C_{19}H_{18}NO_{22}$, which under the influence of sunlight might split up into $C_{16}H_6NO_2$ (white indigo) plus 3 of carbonic acid 3 (CO_2) plus 12 of water 12 (HO). If, however, another equivalent of hydrogen was oxidized, blue indigo is formed, $C_{16}H_5NO_2$.

In the split up of the juices of flesh the following products are formed:

Urea $C_2H_4N_2O_2$
Kreatine $C_8H_9N_3O_4 + 2$ (HO)
Kreatinine $C_8H_9N_3O_4$
Sarkosine $C_6H_7NO_4$

and it is probable that a similar series may be formed by the split up by the oxidation of the chlorophyll in the flower bud.

Professor Graham, in a classic paper published in the Phil. Trans for 1866, on the absorbtion and dialytic separation of gases by colloid septa, demonstrated that gases behaved very differently if passed through indiarubber or gutta percha membranes, although indiarubber and gutta percha are chemically identical substances. He showed that gases pass membraneous septa most readily, which are easily liquified by pressure. Carbonic acid, therefore, penetrates more easily than hydrogen or oxygen.

Thus, with the time being equal, the volumes of gas which passes through the rubber exppresses the velocity of penetration.

Penetration through rubber in equal times :

	Velocity.
Nitrogen	1
Carbonic Oxide	1·113
Atmospheric Air	1·149
Marsh Gas C_2H_4	2·148
Oxygen	2·556
Hydrogen	5·500
Carbonic Acid	13·585

That is, carbonic acid passes 13½ times more readily than nitrogen. This is not wonderful, considering that carbonic acid is soluble in water, in ether, and volatile oils, and that it is dissolved by the hydrocarbons of the rubber, the rubber being wetted through by the liquified gas, which re-appears as gas into a

vacuum on the other side of the membrane, or into another gas which acts as a vacuum.

He also proved that the effect of temperature on rubber rendered it more permeable to gases as the temperature is elevated. There is no doubt but that the membranous skin of the leaf of a plant behaves in the same manner as the film of indiarubber; moreover, oxygen is twice as soluble in rubber as the same gas in water at the ordinary temperature. It is probable that the membranous skin of the leaf alters its physical condition at various stages of its growth, approaching at its resting period to gutta percha, and its power of absorbtion of the gases would consequently differ at different temperatures and at different seasons of the year. This would be an explanation of the reason why, at certain stages of the plants' growth, the process of the absorbtion of its gases is reversed.

I suspect that the phosphates increase the inflorescence of plants. Last year I watered a Marechal Niel rose in a pot with water containing nitrate of ammonia. Although the plant made a strong growth of 10 feet in length, the flowers were very few in number this year, and badly developed; on the other hand, two Gloire de Dijon roses, which I fed with phosphate of ammonia in addition to the nitrate, had in the one case 93, and in the other over 180 large and fully-expanded blooms open at the same time.

The phosphates are decomposed and reduced to their elements by plants, and phosphorous (P) is liberated. Phosphorus may replace the nitrogen in the

ammonias in organic compounds; in this manner another series of organic products is built up in the constituence of plants.

I believe that the scent of flowers is formed in the flower itself. If pinks or other flowers are cut and placed in water under a bell glass in which a funnel filled with ice and salt has been placed, the ethereal odour of the blossom given off by the flower is deposited on the exterior of the glass funnel and drops into a glass vessel below. If a little ether is volatilised under the bell glass, the whole of the odour can be extracted from the flower, but next day the flower will again regain its scent. Flowers growing on the plant behave in the same manner as cut flowers. The experiment may be repeated two or three times, but after that the flower ceases to make any more scent. I have in this manner extracted the scent of pinks, roses, lilies, and other flowers. I believe that these odours are of the nature of camphors; they are very volatile, and rapidly become sour by oxidation, they have definite crystaline forms, but are very unstable, and liable to change by exposure.

In concluding this letter, I cannot help expressing a hope that the Horticultural Society or Amateur Orchid Growers will raise a fund to be expended in having a thorough analysis made by a professional chemist of the chemical constitution of orchids, together with the mineral and alkaline salts of the flowers, and pseudobulbs of the principle species of orchids, which are in cultivation at different seasons of their growth. I feel convinced that many obscure points in their habits would be cleared up, and a more rational treatment

would follow, in place of the empyric and rule of thumb method of cultivation now in vogue.

I am,

Yours faithfully,

A. H. SMEE.

THE CHEMISTRY OF DAILY LIFE.

The Grange,

April 4th, 1901.

Dear Power,

I do not know whether you have ever considered the experiments made by Graham of the dialytic separation of gases by colloid septa.

Gases appear to have a power of passage through bags made of indiarubber, in order of their power of liquifaction, thus carbonic acid more freely than oxygen, and oxygen than nitrogen. Although indiarubber and gutta percha are chemically the same substance, they do not have the same dialytic action. If air is passed through a bag made of indiarubber by means of Sprengel's pump, the oxygen in the atmosphere is separated from the nitrogen, but if the bag is made of gutta percha tissue, no such separation takes place. In the lung organism I suspect that the iron in hœmatin which is contained in the red blood cells in venous blood is in a state of proto salt, whereas in arterial blood it is in the form of a per-salt; and that the passage of blood cells through the capillary network, with which the lung cells are enveloped, acts in a similar manner to the mercury falling in a Sprengel apparatus, the blood cells in the venous blood readily giving up their carbonic acid, which, as I have stated above, readily passes at each expiration by dialytic action, through the colloidal mucin of the air cell, and the red blood cells at the same time absorb by the same means a fresh supply of oxygen, which they then convey to the tissues of the body. These, I suspect, are the changes which take place in health. I have no doubt, for instance, that the membrane, with its lining of mucin, has the same power of dialytic separation on gases by colloid septa as the indiarubber bag has in the experiment quoted. The indiarubber bag, in fact, may be looked on as a gigantic lung cell. In disease, however, the lung tissue, without undergoing any permanent organic change, becomes, I suspect, modified, undergoing some allotropic alteration, so that both the oxygen and the carbonic acid are imperfectly separated from the blood owing to the altered physical condition of the tissue of the lung cell; consequently, the blood cells get imperfectly aerated.

Let us consider what may happen to albumen by its theoretical destruction by oxygen. The composition of albumen according to the old notation may be taken to be $C_{114}H_{110}N_{18}S_2O_{42}$; if then 152 of oxygen is used the result of the change may be three of sugar ($C_{12}H_{12}O_{12}$), four of uric acid ($C_{10}H_4N_4O_6$), one of urea ($C_2H_4N_2O_2$), two of sulphuric acid, and thirty-six carbonic acid will be given off and fifty-four of water formed; but if the oxygen is increased to 224 then the sugar will be lost, and there will remain four of uric acid, one of urea, two of sulphuric acid, ninety of water, and seventy-two of carbonic acid will be given off; but if the oxygen is increased to 248 the whole of the sugar and uric acid will disappear, and there will remain the nine of urea, two of sulphuric acid. seventy-four water, and ninety-six of carbonic acid. Many other substances—such as kreatine, kreatinine, sarkosine, tyrosine, globulin, and many other intermediate products—are formed by the conversion of albumen. These I have purposely omitted from the theoretical consideration of the products produced by the ultimate oxidation of albumen. I do not for one moment suppose that in nature these changes are completely carried out, but I believe fibrous tissue and muscle get converted into urea. The chondrin, cartilage, skin, and the mucin of the serous fluids, into which albumen gets converted (see my paper on fibrin and mucin), according to whether oxidation of these substances in the body has been more or less perfectly carried out, so we get urea, uric acid and sugar formed and eliminated by the kidney.

In diseases which interfere with the proper oxidation of the red blood cells, for instance pneumonia and bronchitis, more uric acid is always found in the urine, and I have frequently found traces of sugar in the urine of persons who have not been diabetic subjects. When there has been an excess of uric acid and I have been able to determine the quantity of sugar by the polariscope, you can see the extreme folly of feeding persons suffering from pneumonia and bronchitis with foods rich in hydro-carbons. In such circumstances, more and more carbonic acid must form and accumulate in the blood vessels, because the colloid mucus of the lung cell is so altered that the dialytic separation of the carbonic acid from the

blood cells cannot fully take place, and thus the person slowly asphyxiates in a similar manner to what would happen if coal was piled on the stove and the register shut down. You will no doubt remember when I was working with diabetic urine, I at times found that urine with a high specific gravity contained little or no sugar, and that by keeping it for a short time at the temperature of the body, and passing oxygen into it by means of a coil of platinized platinum wire, not only did the specific gravity of urine fall but the sugar increased. For instance, a urine with a specific gravity of 1036 contained 17·5 grains of sugar. After a few hours the specific gravity had fallen to 1032 and the sugar had increased to 29·4 grains per ounce. Similarly, when peroxide of hydrogen had been added the sugar increased to 25·1. But this increase of sugar only happens when some substance which is capable of conversion into sugar is present in the urine, and almost always occurs in urine passed shortly after food containing large quantities of nitrogenous matter has been eaten.

I have noticed that after a patient had been breathing oxygen gas derived from the decomposition of water, the quantity of sugar increased and the specific gravity decreased, but this is due to nitrogenous matter in the blood vessels in process of oxidation.

Before.			After.		
Sp. G.		Sugar per oz.	Sp. G.		Sugar per oz.
1035	...	23·5	1026	...	29·8
1038	...	22·4	1035	...	25·5
1035	...	16·8	1030	...	19·9
1032	...	19·9	1031	...	24·3

The splitting up of albumen is very similar to the changes that take place in the incubation of a fertilized egg. Let us consider what happens. The albumen is kept in its place by the chalaza bodies which are attached near the poles of the yolk and the extremities of the egg. The yolk is a phosphorized oil and the whole is enveloped in a stout membrane, which is protected by a calcium shell. During incubation the egg segments into an oxygen and hydrogen pole. At the oxygen pole, connective tissue, fibrin and muscle is formed; at the hydrogen pole, chondrin, the animal matter of bones,

skin, and the mucins are formed. Air is respired through the membrane within the egg shell; for if the egg-shell is varnished no change takes place. The embryo during the incubating period lives on the phosphorized oil of the yolk, the calcium of the egg-shell gets thinner and loses weight, and during the incubation unites with the phosphorous of the yolk and forms the phosphate of lime of the bones. In the case of fish and frog spawn, which are not enveloped in a calcium shell, they derive their oxygen and lime from the water in which the spawn has been deposited.

I cannot help thinking that much of the so-called albumen of intermittent albuminuria is not true albumen, but is a peptone. If food of albuminoid origin is acted on by the gastric juice, a peptone is formed which is capable of passing through a membrane. Albumen, which is a colloid, has little power of passing through membranes. Picric acid and some other delicate tests for albumen also re-act on peptones. The presence of small quantities of these substances, which have a power of dialysis, has a very different physiological significence to albumen. I am very sceptical as to the value of results obtained in the hands of the ordinary medical practitioner by these delicate tests. They cannot be considered to have the training of professional chemists, and it is very probable that many other substances which are not true albumen may be precipitated by these re-agents, especially in the hands of persons who have only a very superficial chemical training. We have lately had an example of the difficulty even professional analysts have in particular instances, when dealing with minute quantities, of obtaining anything like accurate results. Take for instance the arsenical beer cases. The same beer has been reported upon by competent analysts to contain $\frac{1}{5}$th, $\frac{1}{15}$th, $\frac{1}{30}$th, $\frac{1}{40}$th, and $\frac{1}{50}$th of a grain of arsenical acid per gallon. When such a great diversity of result can take place in the hands of experts, it is not to be wondered at that the examination by ordinary medical practitioners of the complex organic substances found in urine should be very liable to error. I have no doubt if the urine of a considerable proportion of persons who, after attending a heavy banquet, had sat for hours in a vitiated atmosphere, was examined by some of these

delicate tests such urine would be reported upon as containing albumen, when in fact it would probably contain a peptone and not true albumen. I do not think that for the ordinary medical man there is any better test for albumen than by boiling the urine. If a flocculent deposit remains after the addition of nitric acid, then a medical man may feel justified in diagnosing the presence of albumen; this is quite sufficiently accurate for clinical purposes. These delicato tests should only be used by the professional chemist, otherwise, other organic substances may be found at times in healthy urine, and may be mistaken for albumen and errors of diagnosis will result.

Yours faithfully,

A. H. SMEE.

To W. H. Power, F.R.S.

THE

CAUSES OF DEATH

AT THE

CITY OF LONDON HOSPITAL FOR DISEASES OF THE CHEST,

VICTORIA PARK,

FROM THE

OPENING of the ESTABLISHMENT, 1848,

TO

31st DECEMBER, 1868.

The examination of the Causes of Death of persons who died at the Hospital for Diseases of the Chest, from the opening of the Hospital to December, 1868, shows that 434 persons died of Consumption, of which 96 died under 20 years of age, 100 between 21—25, 83 between 26—30, 57 between 31—35, 43 between 36—40, 26 between 41—45, 18 between 46—50, and 11 over 50 years of age. It also shows that a large proportion of deaths occurred before 25 years of age. In the case of women generally the proportion reached 60 per cent., of men employed out of doors 42 per cent., of those partly employed in and partly out of doors 41, whilst of males exposed to the weather only 30 per cent. died before attaining the age indicated.

The duration of the disease is less than six months in 46 per cent. of females, and that of the males indoor occupation, 37 per cent., 37 per cent. for males employed partly indoor and partly outdoor, and 30 per cent. of males exposed to the weather. Of the 434 deaths from Consumption, 183 suffered from secondary complications, the chief of which were Diarrhœa 35, Laryngeal mischief 16, Pneumo Thorax 15, Pneumonia 12, Hœmoptysis 22, Pleurisy 17, Kidney troubles 17, and only one from Rheumatism. I have never known in my experience, extending over 40 years, more than four cases of persons who have had Rheumatic Fever ever dying subsequently from Consumption. It looks as if the uric acid diathesis of Rheumatism is a protection for persons against Tubercular disease. Rheumatic Fever appears to give a far greater protection against tubercular disease than vaccination does against Small Pox.

Deaths at Victoria Park Hospital from Consumption.

Table shewing the influence an occupation has on the age at death.

Occupation.	20	25	30	35	40	45	50	55	60	65	Not stated	Totals
Female lives ..	45	41	25	15	12	3	1	1				143
Males. Indoor occupation	32	31	30	24	15	9	5				4	150
Males. Mixed ,,	10	7	7	5	4	3	4				1	41
Males. Outdoor ,,	9	21	21	13	12	11	8	2	1		2	100
	96	100	83	57	43	26	18	3	1		7	434

The same reduced to per centages at each occupation.

Occupation.	20	25	30	35	40	45	50	55	60	65	Not stated	Totals
Female lives ..	32	28	18	11	8	2	1	1				100
Males. Indoor occupation	21	21	20	16	10	7	3				2	100
Males. Mixed ,,	24	17	17	12	10	7	10				3	100
Males. Outdoor ,,	9	21	21	13	12	11	8	2	1		2	100
	86	87	76	52	40	27	22	3	1		7	400

Duration of the disease in months.

Occupation.	3 months.	6 months.	12 months.	18 months.	2 years.	3 years.	Upwards	Not stated.
Female	28	37	34	10	12	6	8	8
Males. Indoor occupation ..	37	19	44	12	11	5	9	13
Males. Mixed ,,	7	8	8	6	6	1	3	2
Males. Outdoor ,,	18	22	28	12	8	2	4	6
	90	86	114	40	37	14	24	29

Duration per cent. in months.

Occupation.	3 months.	6 months.	12 months.	18 months.	2 years.	3 years.	Upwards	Not stated.
Female	20	26	23	7	8	4	6	6
Males. Indoor occupation ..	24	13	29	8	7	4	6	9
Males. Mixed ,,	17	20	20	14	14	2	8	15
Males. Outdoor ,,	18	22	28	12	8	2	4	6

Employments of Females.

Occupation.	20	25	30	35	40	45	50	55	60	65	Not stated	Totals
Servants	19	18	8	7	2	1	1					56
At home, married ..	1	6	7	5	6	1						26
,, single ..	12	1	4	1								18
Dressmakers	4	9	5	2	2							22
Governesses	2	2			1							5
Other occupations, such as Flower Makers, &c.	7	5	1		1	1		1				16
	45	41	25	15	12	3	1	1				143

Males, indoor employments.

Occupation.	20	25	30	35	40	45	50	55	60	65	Not stated	Totals
Clerks	9	8	5	5			1				1	29
Shop employed ..	11	3	7	3	4						1	29
Workers in wood ..	6	5	3	4	4	5						27
,, with metals ..	3	3	2	3	4						1	16
Other mechanics ..	2	4	9	2	2	3	2					24
Servants	1	6	3	4	1	1	1					17
Exposed to the sale and use of intoxicating drinks		2	1	3			1				1	8
	32	31	30	24	15	9	5				4	150

Males, mixed employments.

Occupation.	20	25	30	35	40	45	50	55	60	65	Not stated	Totals
Blacksmith	3	1	1	1								6
Coopers	2											2
Painters	1	1	2			1						5
Gasfitter	1		1									2
Ropemakers		2										2
Warehousemen ..		1	1				2					4
Commercial Traveller				1	2		2					5
Professions		2	1	2	2	1					1	9
No occupation	3		1	1		1						6
	10	7	7	5	4	3	4				1	41

Males, outdoor employment.

Occupation.	20	25	30	35	40	45	50	55	60	65	Not stated	Totals
Laborer	2	8	9	7	5	1	3	1	1		2	39
Employed on Railways	1	2	1	2		2						8
„ about Animals		5	4	1	5	5	2					22
Sailors	3	1	2					1				7
Police		2	1	1	1	1						6
Postmen		1	1	1								3
Sawyer		1										1
Bricklayer	1				1		1					3
Shipwright	1		2			1	1					5
Stonemason	1		1	1		1						4
Musician		1										1
Chairman						1						1
	9	21	21	13	12	11	8	2	1		2	100

Deaths from other diseases of lungs.

Occupation.	20	25	30	35	40	45	50	55	60	65	Not stated	Totals
Females	3			1	1							5
Indoor employment.. Males.			1		1	1	1	1				5
Mixed „ Males.				2		1						3
Outdoor „ Males.			1	2					1			4
	3		2	5	2	2	1	1	1			17

Deaths from malignant disease.

Occupation.	20	25	30	35	40	45	50	55	60	65	Not stated	Totals
Females	1	1	1									3
Males. Indoor employment..	1			2		1		1				5
Males. Mixed ,,	1						1					2
Males. Outdoor ,,							1					1
	3	1	1	2		1	2	1				11

Deaths from heart disease.

* 10 deaths of female children under 15 years of age.

Occupation.	20	25	30	35	40	45	50	55	60	65	Not stated	Totals
Females	15*	2	3		1							21
Males. Indoor employment..	1	1			1		1	2				6
Males. Mixed ,,	1	1	1		1							4
Males. Outdoor ,,	2	2	2		1	1					1	9
* 10 under 15 years.	19	6	6		4	1	1	2			1	40

Deaths from other diseases.

Occupation.	20	25	30	35	40	45	50	55	60	65	Not stated	Totals
Females	1	2										3
Males. Indoor employment..												
Males. Mixed ,,	1											1
Males. Outdoor ,,				1	2			1				4
	2	2		1	2			1				8

General Summary.

Deaths from all causes from the formation of the Hospital in 1848 to 31st December, 1868.

Occupation.	20	25	30	35	40	45	50	55	60	65	Not stated	Totals
Phthisis	96	100	83	57	43	26	18	3	1		7	434
Other lung diseases ..	3		2	5	2	2	1	1	1			17
Malignant	3	1	1	2		1	2	1				11
Heart disease	19	6	6		4	1	1	2			1	40
Miscellaneous	2	2		1	2			1				8
	123	109	92	65	71	30	22	8	2		8	510

Table shewing the number and nature of the secondary complications that happened to the 434 fatal cases of Phthisis.

2nd complication.	Females.	Males.			Totals.
		Indoor employment.	Mixed.	Outdoor.	
Pyœmia	1				1
Diarrhœa	10	13	4	8	35
Dysentery	1	1			2
Rheumatism		1			1
Delirium Tremens ..		1			1
Fistula	2	2			4
Cancer			1		1
Brain symptoms ..	2	4	2	3	11
Heart		1	1	2	4
Laryngeal	3	9	1	3	16
Pneums Thorax ..	4	8		3	15
Empyema				2	2
Emphysema	4	3		2	9
Pneumonia	4	3	1	4	12
Pleurisy	5	6	1	5	17
Hœmophysis	1	12	4	5	22
Hepatic	1	1			2
Enteric disease ..	2	2			4
Ascites	2	2		1	5
Peritonitis			1		1
Kidneys	6	6	1	4	17
Spleen				1	1
Dropsy	1	1			2
	49	76	17	43	185

DEATHS FROM DIPHTHERIA.

The following Tables give the nnmber of deaths per 100,000 living for the decennial periods 1851—60 and 1861—70, for males and females, in the Registration Districts of England and Wales in age periods, also the deaths from all ages, and the deaths per 1,000 living together with the density of the population.

District.	Density of Population.		Annual Mortality.	Deaths from Diphtheria.—Radix 100,000.																			
	Acres to a person 1851	Persons to an acre —60.	Deaths to 1,000 living 1851—60.	All Ages.	0		1		2		3		4		Under 5.		5--9		10—15		15 & Upws.		
					Male.	Female.	Male.	Female.	Male.	Female.	Male.	Female.	Male.	Female.	Male.	Female.	Male.	Female.	Male.	Female.	Male.	Female.	
London	·03	33·34	24	8	..	..	..	..	..	..	..	..	..	..	40	39	12	17	3	6	1	1	
North Western Counties .	·74	1·35	26	6	..	..	..	..	..	..	..	..	..	..	28	28	11	12	4	5	1	1	
Yorkshire	1·92	·52	23	13	..	..	..	..	..	..	..	..	..	..	53	55	25	34	8	13	2	2	
Northern Counties .. .	3·29	·30	22	9	..	..	..	..	..	..	..	..	..	..	37	37	20	21	8	8	1	2	
South-Eastern Counties .	2·34	·43	20	15	..	..	..	..	..	..	..	..	..	..	51	53	37	45	12	22	2	3	
South Midland Counties ..	2·53	·40	20	8	..	..	..	..	Not	given	..	..	..	..	30	27	18	18	6	7	2	1	
Eastern Counties .. .	2·85	·35	21	14	..	..	..	..	..	..	..	..	..	..	42	40	35	42	13	20	3	3	
South Western Counties ..	2·74	·36	20	10	..	..	..	..	..	..	..	..	..	..	41	41	20	25	7	11	1	1	
West-Midland Counties ..	1·69	·59	22	12	..	..	..	..	..	..	..	..	..	..	48	50	23	31	9	14	1	2	
North-Midland Counties ..	2·83	·35	21	21	..	..	..	..	..	..	..	..	..	..	77	79	45	53	21	24	3	4	
Monmouthshire and Wales	4·18	·24	21	10	..	..	..	..	..	..	..	..	..	..	38	32	22	25	10	16	2	2	

District.	Density of Population.		Annual Mortality.	Deaths from Diphtheria.—Radix 100,000.																			
				All Ages	0		1		2		3		4		Under 5.		5–9		10–15		15 & Upws.		
	Acres to a person 1861	Persons to an acre —70.	Deaths to 1,000 living 1861–70.		Male.	Female.	Male.	Female.	Male.	Female.	Male.	Female.	Male.	Female.	Male.	Female.	Male.	Female.	Male.	Female.	Male.	Female.	
All England	1·74	·57	22	33	66	50	93	89	76	84	80	80	66	66	75	78	33	45	11	17	3	3	
London	·02	50·06	24	33	87	64	121	119	98	115	88	95	65	78	92	93	25	34	4	9	3	3	
North Western Counties ..	·63	1 59	26	31	71	59	118	118	76	94	74	81	62	79	80	85	28	34	6	10	2	2	
Yorkshire	1·68	·60	24	32	66	53	86	78	74	82	81	79	53	78	72	73	35	44	11	15	3	3	
Northern Counties	2·77	·36	23	27	75	46	101	82	59	67	65	80	48	62	66	67	27	33	8	14	3	3	
South Eastern Counties .	1·99	·50	19	37	43	44	73	76	71	73	115	93	84	98	73	75	43	58	14	25	3	4	
South Midland Counties ..	1·50	·67	20	33	57	39	61	66	71	73	78	87	66	83	66	69	34	42	9	16	3	3	
Eastern Counties	2·72	·37	20	52	56	48	87	72	98	107	108	125	105	134	90	96	63	88	24	40	7	7	
South-Western Counties ..	2 68	·37	20	22	51	28	57	51	46	47	51	58	44	66	50	49	22	33	9	9	2	2	
West-Midland Counties ..	1·50	·67	22	34	71	53	106	107	82	86	83	89	71	79	82	82	31	46	11	15	3	3	
North Midland Counties ..	2·62	·38	21	36	65	55	68	72	72	93	79	93	70	74	70	77	41	52	15	24	4	4	
Monmouthshire and Wales	3 79	·26	21	36	57	40	87	75	79	70	72	91	64	86	71	72	45	54	17	25	4	5	

DEATHS FROM DIPHTHERIA.

This Table gives the number of deaths per 100,000 living for the decennial period 1861—70, for males, females, and both combined, in the Registration District of London, compared with England and Wales and London as a whole, in the age periods from 0 to 15 and upwards.

District.	Age.																										
	0			1			2			3			4			Under 5.			5			10			15 & Upwds.		
	Male	F'ale	Both	Male	F'ale	Both	Male	F'ale	Both	Male	F'ale	Both	Male	F'ale	Both	Male	F'ale	Both	Male	F'ale	Both	Male	F'ale	Both	Male	F'ale	Both
England and Wales	66	50	58	93	89	91	76	84	80	80	87	83	66	82	73	75	78	76	33	45	39	11	17	14	3	3	3
London	87	64	76	121	119	120	98	115	106	88	95	91	65	78	72	92	93	93	25	34	30	4	9	6	3	3	3
Kensington	119	71	95	117	115	116	129	102	115	121	149	13	128	92	110	123	105	114	35	43	38	5	9	8	4	5	4
Chelsea	95	21	58	142	111	126	89	65	77	85	62	73	13	68	43	86	64	76	17	37	27	3	3	3	2	2	2
St. George's, Hanover Square ..	142	69	106	73	84	77	145	150	124	173	199	186	80	93	86	124	107	116	45	52	48	..	18	10	6	4	5
Westminster (St. Margaret's) ..	32	84	58	174	39	150	53	74	64	40	65	52	88	71	76	74	67	70	21	28	24	7	3	5	4	4	4
Westminster (St. James' and Strand)	109	58	83	94	113	104	92	134	113	54	161	108	45	55	50	81	102	92	25	19	22	26	50	38	2	2	2
Marylebone	116	73	95	159	139	149	76	195	136	91	99	95	63	86	74	103	117	111	28	42	35	7	7	7	4	3	3
Hampstead	..	135	65	76	222	150	222	182	202	186	68	125	37	146	92	101	149	125	34	46	40	10	29	21	5	2	3
Paneras	72	89	76	159	179	170	155	141	148	129	130	130	115	92	104	125	124	124	37	47	42	5	7	6	3	3	3
Islington	119	42	81	137	133	135	78	125	101	116	87	102	57	70	64	103	90	96	19	45	32	2	16	9	3	2	3
Hackney..	125	59	91	91	105	98	69	83	76	61	59	60	70	111	91	84	82	83	26	51	39	8	10	9	3	3	3
St. Giles'	123	56	90	127	50	86	84	120	102	103	37	72	19	56	38	94	64	79	16	32	24	4	4	4	2	4	3
Holborn	104	72	88	154	152	153	140	154	147	141	129	135	72	133	103	122	126	123	23	29	27	3	3	3	2	2	2
East London	60	105	82	172	146	158	129	121	125	26	104	66	53	105	89	88	116	102	17	33	25	5	..	3	5	1	3
West London	98	..	49	302	239	269	253	152	199	141	118	128	50	86	69	169	115	140	29	61	45	30	20	25	7	5	6
London, City	192	157	174	203	206	205	35	127	83	36	66	52	75	68	72	114	126	120	44	27	35	..	..	..	1	2	1
Shoreditch	97	69	83	114	148	131	90	90	90	72	120	96	49	83	66	86	101	93	20	22	21	6	8	7	2	2	2
Bethnal Green	35	41	38	54	89	71	30	78	77	49	61	55	19	46	32	37	63	50	9	22	15	1	2	2	1	2	1
Whitechapel	44	42	43	4	8	6	51	44	46	86	32	59	33	63	48	51	50	50	17	5	11	..	5	3	1	4	3
St. George's in East	136	62	99	141	113	127	111	74	92	62	62	62	65	143	105	105	89	97	7	29	18	..	4	2	2	1	2
Stepney	86	34	61	246	103	175	152	116	134	90	53	72	53	77	65	124	76	101	20	12	16	3	13	9	2	1	2
Mile End, Old Town	36	36	36	60	97	80	68	84	76	41	105	72	28	37	32	47	71	59	15	28	22	..	7	4	4	2	3
Poplar	53	65	59	76	82	79	104	108	106	55	104	79	51	50	50	67	82	74	16	27	21	6	6	6	1	2	2
St. Saviour's, Southwark	94	44	69	84	110	97	95	132	114	67	49	58	50	61	55	79	78	79	27	23	25	3	2	3	1	2	2
St. Olave's, Southwark	67	62	64	151	102	122	54	60	57	63	27	42	66	37	49	80	58	67	13	15	14	3	4	3	2	2	2
Lambeth	56	50	53	72	122	97	94	108	101	68	115	92	48	52	50	67	88	78	20	32	27	7	6	6	2	1	2
Wandsworth	49	55	52	129	45	87	62	83	73	63	68	66	49	109	80	71	71	71	37	50	43	6	16	11	4	3	4
Camberwell	92	101	96	107	136	121	96	73	84	55	74	65	59	76	68	82	92	87	43	44	44	8	22	16	4	3	4
Greenwich	123	107	115	177	111	145	118	144	131	141	116	128	81	77	79	128	112	120	21	22	23	3	16	9	4	3	4
Lewisham	41	41	41	98	111	105	96	206	152	61	76	69	115	91	103	81	101	92	11	64	54	..	10	5	3	4	4

SOUNDS AND FOG.

From "The Times," *September 20th*, 1875.

TO THE EDITOR OF "THE TIMES."

Sir,—It has been stated in the evidence given before the Court-Martial on the loss of the Vanguard that the steam whistle of the Iron Duke could not be heard. Perhaps the following notes on sea fogs, taken when cruising in the Channel and Estuary of the Thames, will be of interest to your readers. I have noticed that sea fogs appear to be of two descriptions—one in which sounds are distinctly audible, and the other, and far more dangerous, when sounds are muffled or totally obscured. The phenomenon of audibility or inaudibility is not affected by the presence or absence of wind. As illustrations of the first class of fog, I may mention that last summer, when crossing from Calais, a fog came on off the middle (south) Goodwin Lightship. The fog was so thick that you could not see more than a quarter of a mile ahead; a very light air of wind was blowing at the time; nevertheless, the steam fog-horn of the South Foreland Lighthouse was distinctly heard, about ten miles distant. At another time this summer, when brought up off Walton-on-the-Naze, the voices of people on shore could be distinctly heard; when the fog lifted we discovered that our position was over three-quarters of a mile from the beach. I have frequently stood on the jetty at Leigh and heard during a fog the steam whistles and beating of the paddles of steamers proceeding up the Thames on the other side of Canvey Island, $2\frac{1}{2}$ miles distant. On the other hand, last

winter, the Tuesday before Christmas, in a thick, frosty fog which enveloped the river, the ships' bells could not be heard until you were so close that the riding lights could be seen, and then the sound was like the distant tinkling of a sheep bell rather than the full tone ring of a ship bell. A strong N.W. breeze was blowing at the time. I have been on Canvey Island in foggy weather, and have been unable to hear the bell at the Chapman Head, a quarter of a mile distant. On one occasion, when brought up in Lower Hope in a fog, surrounded with vessels, it being a dead calm, I was unable to hear the bells of the ships. At times it was so thick that the riding light was almost invisible standing at the helm, about 15ft. off. The question of the transmission of sounds through a fog is a problem well worth the serious attention of the scientific advisers to the Trinity Board.

I am, Sir, your obedient servant,

A. H. SMEE, R.L.Y.C.

The Snowfleck, Erith, Sept. 17.

THE FUTURE WATER SUPPLY OF SURREY.

LETTER TO THE RIGHT HON. THE EARL OF ONSLOW.

My Lord,

At the risk of being considered a bore and a faddist, I have ventured to put before you my views as to the future of the water supply for the inhabitants of Surrey, and its relation to the proposal of the Government to create a water trust. The question for members of the Surrey County Council is to consider whether the provisions of this trust will protect the sources of supply for the inhabitants of the county as a whole.

You are no doubt in the triple position of being first an active supporter and promoter of the Bill; secondly, as a member of the London County Council, solicitous of the welfare of the ratepayers of the County of London; and thirdly, as a resident and landowner in the rural part of Surrey, you are interested in the future welfare of the extension of the population of the county, and the adequacy of its water supply.

It may be doubted whether a member of the Board elected, as proposed by the Bill, will have the requisite training to deal with the complex problems which are evolved in the management of the Metropolitan water companies. I think this is open to doubt, and and will probably end in handing over the control to the permanent officials. It is my belief that the members of this Board will have to be paid a large salary. A daily attendance will be necessary to superintend the management. The success of a water company depends on the supervision of minute details, so as to prevent waste. As an illustration, in a district in the south of England with which I am acquainted, there is a town partly supplied by the local authorities, the other by a local water company. In the latter district the consumption is something like fifteen gallons per head, and in that part managed by the local authorities the consumption has been as high as fifty gallons, which means, of course, a very considerable waste and unnecessary expense. The board of the water company, having to provide a dividend for their shareholders, are obliged to see that no undue waste takes place, but this is only a minor point. The real issue for Surrey to consider is whether the sources of supply have been adequately protected.

The source of supply may be divided into two parts, those towns and villages which derive their supply from the Thames valley, and those which derive their supply from other sources within the county.

The Southwark and Vauxhall and Lambeth Companies, which supply part of the Metropolis and part of Suburban London, have the right to arrest and extract a definite quantity of water per day from the Thames as the water flows past their intakes on its way to the sea. This right is of the nature of an easement, for the companies cannot control the sources which are not within the boundary of the county. The water at these sources may be so intercepted and diverted by the other authorities that it will never reach the Thames, and so will not pass these companies' intakes. It is not, therefore, strictly a source of supply.

The other rivers of Surrey within the administrative area, from which a supply might be drawn, are:—The Graveney, which is being converted into a sewer; the Wandle, which is a chalk river, in summer it formerly brought down more water than any other stream; the Beverley Brook is fed by land drainage, except in Boorne times, when it contains chalk water; the Hog Mill is a chalk stream; the Mole is fed partly by water from the land drainage, partly fed by chalk springs; the Wey in summer is a very sluggish stream, mostly fed by land drainage and from the green sand and chalk; the Blackwater is practically a land drain, the water from which can never be considered a safe source for a water supply. None of these rivers are, as far as I know, used for any regular water supply by the inhabitants of the county.

The soil of Surrey may be divided into three great classes:—The impervious clays, which, of course, are a non-water-bearing strata. Secondly, the Bagshot, Reading, and Woolwich beds, which contain a very uncertain quantity of water, the quality of which is notoriously bad, and utterly unsuited for domestic supply. During the last thirty years in this part of Surrey, although the population in this district has been sparse, and the communities very scattered, they have suffered repeatedly from diphtheria, the virulence of the outbreaks being altogether disproportionate to the density of the

population. The question of a water supply for this portion of Surrey will become a serious problem as this part of the county becomes filled with inhabitants, as they depend largely for a supply from shallow wells. Thirdly, the chalk and green sand from which the principal towns, townships, and villages derive their supply.

Looking at the geological map, these beds of chalk and green sand spread through the middle of Surrey like a comet, with the head near Caterham, and with the tail running out towards Guildford.

It is from this area that the inhabitants of Croydon, Caterham, Reigate, Carshalton, Sutton, Epsom, Dorking, Guildford, Godalming, and Woking, and numerous villages derive their water supply.

The percolation over this district may be taken at six inches on an average of years, consequently it will not be a difficult calculation to arrive at the amount available for supplying the towns without the destruction of the rivers.

It must, however, be remembered that the water supply for South London, Kingston, Wimbledon, Richmond, Mitcham, and Barnes is not supplied by the Lambeth and Vauxhall Companies with water derived wholly from the Thames, but some portion is taken from the river gravels, and from deep wells at Streatham, &c., which are sunk into the chalk through the London clays; besides, there are about forty to fifty artesian wells in the South London basin, which are pumping many millions of gallons per day of water derived from the rain which has fallen on the chalk hills of Surrey.

Geological experts consider that the water in the wells in Trafalgar Square, which supply the Government Offices and the Houses of Parliament, and the private wells at Coombe's Brewery, in Long Acre, derive their supply from rain which has fallen in the neighbourhood of Dorking, the nearest point of the outcrop of the green sand to London.

It is rumoured that new wells are to be constructed, one at Merton and the other not far from Raynes Park. These will be sunk through the London clay into the chalk, from which it is expected many million gallons will be obtained, making, of course, a further drain on the water in the chalk hills of Surrey.

The water level in the chalk under the clays of the London basin has fallen year by year, at the rate of varying from three to twelve inches per annum.

The effect of which is to make the water gradient steeper, and consequently tend to a more rapid flow, lowering the water levels at the outcrop on the Surrey hills ; this flow is retarded and held back by the pressure of the super-imposing clay, and the friction of its passage through the narrow but well-defined fissures and channels in the chalk.

Tens of thousands of tons of chalk are removed in the water and held in suspension as bicarbonate of lime every year ; it necessarily follows that the walls of these fissures and channels are slowly but constantly dissolved, thus increasing their size and allowing for a freer passage of the water.

The effect of this constant pumping and the increasing number of artesian wells in London has been to decrease the volume of water in the Wandle.

There has been a very appreciable diminution in the last thirty years of the quantity of water flowing down this river in the low water period, demonstrating conclusively that the reserve of the water held up in the chalk of the Surrey hills has been materially lessened by this constant abstraction of water by wells outside the administrative county. I believe that at the period of minimum flow the whole of the water of the Croydon branch of the Wandle might be passed through a 15in. pipe.

Not only has the quantity of water in our chalk hills been reduced, but the quality has been prejudicially affected by the reckless manner sewage farms and the cemeteries of public institutions have been dumped down on this limited water-bearing strata.

Chalk, although it may act as a filter to coarse particles, is not, and never can be, a purifier of the products of the decomposition of animal organic matter deposited in the soil above the permanent water level. The only means for the destruction of these products is the very limited quantity of oxygen carried down by the rain, consequently we may expect that the chalk soil will become slowly and surely impregnated with decomposing organic matter. The longer

the time it takes to saturate the soil the longer will it take to purify ; having once become polluted a century would probably be required to remove the organic matter from chalk above the water level when once saturated. Considering the serious outbreaks which have resulted from water derived from chalk having become contaminated by specific pollution, the necessity for preserving the purity of the chalk, rural Surrey's only watershed, must be apparent to all. Let me recall to your recollection the serious outbreaks of fever at Caterham, Croydon, Beverley, and more recently at Worthing and Newport, Isle of Wight, and many other places, caused by very minute quantities of specific pollution having found access to the water in the chalk. It is a most serious question, and well worthy the attention of the Government and County Councils.

This pollution of the chalk is increasing year by year, and there is an imminent risk of the water supply of Epsom, Sutton, and Basingstoke being affected. Not only is the chalk of Surrey in danger of pollution, but the water supply of Kent, Hampshire, Sussex, and counties on the north side of London is *mutatis mutandis*, in a similar condition. I believe that in the early part of next century the inhabitants of the towns and villages in rural Surrey, excluding that portion of administrative Surrey supplied from the Thames Valley, will be in serious difficulties as to their water supply. Not only will the number of inhabitants in rural Surrey increase, but the amount of water available for domestic purposes be constantly diminished by the increase of the pumping in the deep wells of the London basin. Large areas of the gathering ground on the chalk hills will have become absolutely useless for domestic purposes by the reckless contamination of the soil which is now taking place at Banstead Asylum and similar institutions.

I have endeavoured to briefly sketch out in this letter my views as to the position of the future water supply of the inhabitants of Surrey.

Where, then, will a pure supply be obtained? Certainly not within the administrative county. Will other counties, then, permit their water areas to be utilised for the benefit of Surrey? Do the proposals and clauses in the Water Trust fulfil the conditions for the

protection of the sources of supply for the whole of the inhabitants, or do they sacrifice the rural districts for the benefit of what may be considered the metropolitan area ?

Yours faithfully,

A. H. SMEE.

To The Right Hon. Lord Onslow.

CRITICISM

On the proposed agreement between the County of Surrey and the County of London in the event of the County of London acquiring the Metropolitan Water Companies.

This letter was written in 1897 for the purpose of calling the attention of the members of the Surrey County Council to the agreement which had been entered into between the Councils of London and Surrey, in view of the event of the proposed acquisition of the London Water Companies by the former body. It appeared to me that the interest of the County of Surrey was not sufficiently protected by the agreement, for it limited the future increase in the quantity of water to be assigned to Surrey to 20 per cent., although it is plain that the population of the administrative County would increase in future at a greater rate than that of the County of London, which is fast approaching to its limit, as comparatively small amount of open spaces have been left to be built upon. I also desire to call attention to the very large capital that would be required, not only to purchase the Lambeth and Vauxhall Companies, but also to the expenditure which would be required for new works in consequence of a separation of the areas over which these companies supply water.

The Grange,
Wallington,
February 25th, 1897.

Dear Mr. Halsey,

Since our Council Meeting I have had an opportunity of showing the agreement entered into between the County Councils of London and Surrey, in the event of the Lambeth and Vauxhall Water Bills passing, to my colleague, who is managing director of two water companies. He is an engineer who has had a life-long experience in water undertakings. His opinion was that a 20 per cent. limit in respect of future requirements was fatal—in

fact, he would never be a consenting party to any agreement which restricted the amount of supply. He said it was his opinion that it should be fought out to the bitter end, because better terms might be obtained in committee.

I should like to point out to you that by this agreement Surrey is restricted, including the 20 per cent. to be added, to something like 3½ million gallons per day; on the other hand, the effect of the agreement will be to aid and abet London and other authorities outside the administrative county obtaining six million gallons which is at present available for the county, but which will be diverted from the county by the splitting up of the Lambeth and Vauxhall Company. The ultimate result will be that Surrey will lose 2½ millions per day by the transaction. Surely that is not to the interest of the county.

Then again, I should like to point out that there is in this agreement no power to restrict the London County Council from sinking new wells, laying new mains, enlarging storage or service reservoirs in any part of the district now occupied by the Lambeth-Vauxhall Companies, and thus obtaining additional supply of water, to the prejudice of the inhabitants of Surrey. It will be quite possible for the London County Council to construct those works out of surplus revenue derived from their water undertaking. In this event they will not have to obtain the sanction of the Local Government Board for a loan, or require the aid of Parliament for new powers. I know Corporations who have, and are at present using, revenue for capital expenditure, thus escaping criticism by Whitehall or Parliament.

Then it will be open to them, by entering into an agreement with a landowner, to take a lease for a term of years, to sink wells and drive adits on his property. It is within my knowledge that a water company in Surrey has, in the last eighteen months, rented land for a period of years for the purpose of sinking wells and driving adits. There is nothing to prevent myself or any other land owner sinking wells, driving adits, and entering into an agreement to sell water in bulk to London or any other authority. *I know of no legal impediment, under the Water Works Act of* 1847, *to prevent an owner*

of land entering into an agreement with a water authority, whereby that authority may lay down a main and lease the same for a term of years to the owner of such land, and to pass water through such main as through traffic to any point or boundary of the district, upon such terms as may be agreed upon by the landowner and water authority, provided the water authority gives a sufficient supply of water to the inhabitants of the district for domestic purposes. If I am right in my contention, it would be feasible for six or eight landowners to enter into similar agreements, which in effect would dry up the Wandle, the Mole, and Hogmill, the principal Surrey rivers.

I believe it would have been to the interest of Surrey to have opposed these Bills in Parliament, and to have tried to have got clauses to something like the following effect inserted :—

(1) The limits of this Act and the Water Acts for the supply of water by the London Council, in this Act called the water limits, shall comprise the town and county of London. Provided always that the London Council may supply water to any lands outside the said county acquired by them under this Act, and to any buildings erected on such land. Provided also that, at the request of the Kingston and Richmond, or other Sanitary Authority, in the county of Surrey, may, if think fit, supply water within the parishes as are coloured red on a map signed and deposited as next hereinafter mentioned, on such terms and conditions as may from time to time be agreed upon between the London Council and the said Sanitary Authorities. Provided that the London Council shall cease to supply water within these parishes when and as soon as the Surrey Council may be in a position to supply water to these parishes.

(2) A map of the limits within which the Council of London may supply water, signed in duplicate by the Chairman of the Committee (of House of Lords or Commons) to whom the Bill for this Act was referred, shall, within two weeks after the passing of this Act, be deposited in the office of the Clerk of Parliament, and with the Clerks of the Peace of Surrey and London respectively. If by, or by reason of,

> the construction of the works or alteration in the present works by this Act authorised, the present supply of water to existing houses situate within the limits defined in the map to be deposited, as hereinafter provided, is diminished, the London Council shall, on being thereunto required by the said Sanitary Authorities, furnish a supply of water to such houses.

These clauses are practically identical with clauses which have been inserted in a Water Bill of a Corporation for the protection of a water company, which has passed both Houses of Parliament. The Surrey Council should endeavour to get a clause inserted to this effect:—

> That no existing company, corporation, council of county or borough, or sanitary authority shall, after the passing of this Act, be permitted to sink or dig any new well, or drive any adit, or take water from any pond, stream, or river, or do any other work which may reduce the quantity of water, situated within the county of Surrey, without first obtaining the consent of the Council of the county of Surrey, or by a Provisional Order of the Local Government Board, or by an Act which has received the sanction of the Houses of Parliament.

Assuming that the Council determined to lay out a new system of works for the parishes in Surrey now supplied by the Lambeth and Vauxhall Companies, what would be approximately the amount of capital expenditure?

Taking the S.E.W. figures, which is a district very similar in extent to the Lambeth and Vauxhall districts in Surrey, the population is 85,000, with a capital expenditure of £215,000. To supply 150,000 population on this basis, the expenditure would be £380,000, and adding 10 per cent. for contingencies, £418,000.

If the S.H.W. basis is taken, a company which has a district much larger, but more thinly populated, the basis would be, for a population of 44,000, £143,000, and consequently relatively more expensive. This would require, for a population of 150,000, an expenditure of £487,500, and adding 10 per cent. for contingencies, £536,300.

A high service reservoir would be required near Banstead to govern Wimbledon and part of Richmond, and a low service reservoir somewhere on the high ground between Coombe and Wimbledon to supply Esher, Molesey, Malden, Mitcham, Merton, South Wimbledon, Kingston, the low lying parts of Richmond, Kew, Barnes, and Mortlake. The cost of covered reservoirs may be taken at £5 per 1,000; these reservoirs should have a capacity of two and three millions respectively. Filter beds and open storage reservoirs will probably cost £3 to £3 10s. per 1,000 respectively, as it would be unnecessary to make these with water-tight bottoms. A large amount of water would thus be derived by percolation through the river gravels of the Thames Valley. It might be well to supplement these by sinking deep wells into the chalk, the position of which would depend upon the opinions of geological experts.

If, on the other hand, the Council purchase the plant, mains, &c., of the existing companies, upon the basis of the value of the water rents, there will be, no doubt, great difficulty at arriving at the amount of water supplied to these districts, because the trunk mains have been tapped for services at various points on the route.

Taking 5 per cent. on the rateable value of these districts at £989,000, it would yield a gross revenue of £49,450. Allowing 50 per cent. for working expenses, the net income would be £24,725. At 25 years' purchase, this would require £678,125 to be paid for the existing works to the London County Council, less certain deductions which would have to be made. But to this sum must be added something like £200,000 to £250,000 for placing the existing system in an efficient state. The net expenditure will be not far short of £800,000, for very unsatisfactory old works. On the other hand, a new set of works adapted for these districts might be very well made for £420,000 to £536,000.

If, on the other hand, the basis is to be calculated on the capital expenditure of the Lambeth and Vauxhall Companies at their present value, then the £1,910,000 Debenture and Ordinary Stock of the Lambeth Company is worth at the present market value £4,391,714, to which must be added 10 per cent. for compulsory purchase. This would raise the gross value of the undertaking to £4,830,385. The

£2,412,350 Ordinary and Preference and Debenture Stock of the Vauxhall Company at present prices would be £4,006,616. Add 10 per cent., this would raise the total cost of that undertaking to £4,407,278.

Assuming that one-fifth of the supply of the Lambeth Company would suffice for the present requirements of Surrey, and that the London County Council would be willing to agree to negociate on that basis, throwing the whole cost of the Vauxhall Company on London, Surrey would have to pay for their share of these undertakings £966,177, to which amount would have to be added the cost of re-modelling the works in order to ensure an efficient supply to the parishes of Surrey which are now supplied by these Companies. *Care must be taken that the County, as a whole, will not be made responsible for any loans which will have to be raised for the purchases of Surrey shares in these works. The districts supplied by these Companies will have to provide the funds for the working expenses, the interest, and sinking fund for the reduction of the capital.*

I have made some extracts from Mr. Quick's work on "the principles of compensation involved in the transfer of water undertakings," which may be of service to you and other members of the Council when discussing the various considerations which will have to be taken into account previous to purchase of these undertakings. They are as follows :—

"It behoves a purchasing authority to see that it is really, and "not merely superficially, obtaining money's worth for their money.

"It is proposed, therefore, to discuss the general basis on which "such valuations should be made, premising, however, in this respect "that no hard and fast line can be laid down, and that every case "must stand upon its own particular merits or demerits, as the case "may be.

"The chief points to be examined and determined are :—

"(*a*) The authorized share capital of the Company, and "statutory limitation of dividends in respect of each "class of shares.

"(*b*) The amount of share capital still uncalled, and authorized "dividend upon it.

"(*c*) The authorized loan capital of the Company, and amount "issued.

"(*d*) The gross income.

"(*e*) The working expenses.

"(*f*) The net income.

"(*g*) The reserve or depreciation fund.

"(*h*) The prospective income.

"(*i*) The total amount of the maximum dividends authorized "to be paid.

"(*j*) The rate and amount of dividends paid in every year "from the commencement of the undertaking to the "agreed date of transfer.

"(*k*) The outlay (if any) necessary to enable the existing "income to be earned with certainty.

"(*l*) The outlay (if any) necessary to enable the prospective "income to be earned with certainty.

"(*m*) Condition and capabilities of works and mains in detail.

"Although the particulars of the amount and division of the "capital of the undertaking, debenture debt, &c., appear first in order "in the above list, we must at once explain that, although this "information is necessary to the purchasers, *it ought not, in any way, "to affect the calculation of the value of the undertaking.* It is not the "business of the purchasing authority to inquire into whether the "sellers will gain or lose by the transfer, but to see that they, as "purchasers, will get value present and prospective for the money of "those whom they represent. For the same reason, it is desirable "that the division of the proceeds of the sale amongst the various "classes of shareholders, should be left to be arranged amongst "their own body.

"It is now proposed to offer a few remarks upon the above "headings.

"The *accounts* of the selling Company, for at least three years "subsequent to the proposed purchase, should be submitted to "independent examination by the purchasing authority, in order to "see that the dividends paid are being fairly earned and paid out of "revenue.

"It is also important to analyze in detail how the *income* is made "up, and whether it is of such a character as to justify the probability "of its being maintained in the future.

"As an illustration in point, the author was a few years since "engaged in the valuation of a water works for transfer, when "inquiries similar to the above were instituted with very great advan- "tage to the purchasers, for it appeared, on investigation, that no less "than half of the gross income was derived from two Railway "Companies, and the serious contingencies arose that the Companies "might, at any time, construct works of their own, or dispense with "the Company's supply. This was rightly considered a justification "of the reduction of the number of years' purchase of the income of "the Company.

"In the same way the *expenditure* should not be calculated upon "that of any particular year, but a fair average taken of it, always "bearing in mind that the expenditure should include all such items "for repairs and renewals, and such efficient maintenance of the "works as will enable them to continue to earn the revenue. In the "accounts this may either take the form of the cost of such renewals "being debited to the revenue account of the particular year in which "they are incurred, or of the establishment of a sinking fund to meet "the average depreciation of the perishable portions of the works; "the former is the custom which usually prevails in practice, but the "latter is, strictly speaking, more equitable, and is the argument "which the Water Companies invariably and rightly use in "calculating for rating purposes the net rent which a hypothetical "tenant would give for the concern.

"In connection with the expenditure, it is also essential to "ascertain whether the water works are contributing their legal "quota of taxes, or whether they are liable to increased (or possibly "decreased) assessment; having regard to what we have already "stated upon this subject, the importance of this question is, to both "vendor and purchaser, strikingly apparent.

"Intimately connected also with this question is that of *the* "*condition and capabilities of the works at the time of the transfer*, which "must, necessarily, form a vital element in the purchasers'

"calculations, as the value of the undertaking depends in a great "measure upon their efficiency and capability to continue to earn the "income.

"This point necessarily involves considerations of the source of "the water supply, more especially as regards its quantity and "quality, the adequacy of the works to distribute this quantity at the "necessary pressure, the condition of reservoirs, filters, engines, "mains, meters, and many other matters of a similar character.

"One of the most important of the above items is that relative "to the mains, the condition of many of which is frequently a source "of serious expense in old-established water works which were "constructed when pipes were not subjected to the 'coating' process "invented by Dr. Angus Smith, which has the effect of preserving "them both internally and externally. This 'coating' is not "invariably required; the constituents of the water and the soil in "which the pipes are laid necessitating it or otherwise. In one case "where the author was concerned, this formed a very serious element "in the calculations of value, for upon investigation it was ascertained "that several of the mains had become choked with a deposit of "peroxide of iron, which had the effect of seriously restricting their "carrying capacity; in the case referred to an outlay sufficient to "reimburse the expense of replacing the defective pipes was very "properly claimed on behalf of the purchasers.

"In considering the *capabilities* of the works, regard must be had "not only as to their sufficiency to meet the ordinary requirements of "the district to be supplied, but it is also important to ascertain "whether proper provision has been made in the way of reserve "works, so as to ensure the supply of water being properly main-"tained in case of accident to any part of the works, which, from a "purchaser's point of view, he has clearly a right to expect; on the "other hand, if it should happen that after making provision for "adequately carrying on the works and guarding against con-"tingencies, there should still remain a surplus of engine or other "power, such surplus works should be considered in the light of "provision made towards earning increased revenue, and should be "taken into consideration by the vendors as a credit from any outlay

"which would be necessary to enable an increased income to be "earned.

"The *prospective income* should obviously form a most important "element in the calculations for compensations, for not only "does it involve the question of the maintenance or possible "*diminution* of the existing income, but also that of the *increase* "which, with remarkably few exceptions, takes place in the revenue "derivable from water receipts year by year. Upon this question "the assistance of local experts and vital statisticians should be "invoked, in order to arrive at a proper conclusion upon the special "circumstances of the case under consideration. *The question also of "any additional outlay of capital being required to earn any increased "income must be well considered, and careful estimates made of the cost of "maintenance as such new works as will be necessary.* As an illustration "of this, the annexed Table (prepared by the Author, and handed in "during his evidence in the case of the transfer of the undertakings of "the Stockton and Middlesborough Water Company to the Joint Cor-"porations) may be of service.

"The question of the *divideuds* paid in every year by the selling "Company from the time of its foundation until the date of the "transfer is important, because, as already mentioned, in the majority "of instances, the water works were constructed many years ago "before their importance and usefulness were appreciated as at the "present day, and it has consequently happened that, during the "early years of the Company's existence, the shareholders have either "not received any dividend at all, or something considerably below "that sanctioned by Parliament; this contingency was not unforseen "by the framers of 'The Water Works Clauses Act, 1847,' for it is "'therein provided that 'the profits of the undertaking to be divided "'among the undertakers in any year shall not exceed the prescribed "'rate, or, where no rate is prescribed, they shall not exceed the rate of "'ten pounds in the hundred by the year on the paid-up capital of the "'undertaking, which in such cases shall be deemed the prescribed "'rate, *unless a larger dividend be at any time necessary to make up the "'deficiency of any previous dividend which shall have fallen short of the "'said yearly rate.*'

"Table of Prospective Value, based on the assumption that the "Water Company had obtained an Act of Parliament in 1877 to carry "out Mr. Mansergh's scheme, but excluding the works in the Lune "Valley, and limiting the outlay to £500,000 for new works, plus "£50,000 for distributory mains.

	Years.	Profit remaining after deducting present Statutory Dividend.	New Capital. Four-fifth Share, one-fifth Loan.	Annual Cost of Capital, four-fifths at 5 per cent., one-fifth at 4 per cent.	Surplus Profit.	Deficit.
		£	£	£	£	£
	1877	6,474				
1	1878	8,694	100,000	4,800	3,894	
2	1879	10,914	220,000	10,560	354	
3	1880	10,914	340,000	16,320		5,406
4	1881	10,914	460,000	22,080		11,166
5	1882	10,914	580,000	27,840		16,926
6	1883	15,354 1,700* 17,054	585,000	28,080		11,026
7	1884	19,254	590,000	28,320		9,066
8	1885	21,454	595,000	28,560		7,106
9	1886	23,654	600,000	28,800		5,146
10	1887	25,854	605,000	29,040		3,186
11	1888	28,054	610,000	29,280		1,226
12	1899	30,254	615,000	29,520	734	
13	1890	32,454	620,000	29,760	2,694	
14	1891	34,654	625,000	30,000	4,654	
15	1892	36,854	650,000	30,240	6,614	
					18,944	70,254
						18,944
					Deficit	£51,310

* Saving in pumping expenses.

"It is, therefore, manifestly fair that the shareholders should "receive compensation for the arrears of former dividends, if it can "be proved that they would be receiving them if they continued to "hold the property, but the amount of any such compensation must of "course be dependent upon the special circumstances of each case.

"Assuming the necessary data to enable the items above "enumerated (with such additional details as the special case would "require) to have been ascertained, the purchase money should "consist of:—

"(*a*) Compensation in respect of present net income.

"(*b*) Compensation in respect of future additions to net income.

" (*c*) Compensation in respect of arrears of former dividends.

" (*d*) Compensation in respect of surplus works and property.

" (*e*) Compensation in respect of capital authorized but unissued.

" (*f*) Compensation in respect of compulsory sale.

" These items should be respectively dealt with as follows :—

" (*a*) } Capitalised at present value.
" (*d*) }

" (*b*) }
" (*c*) } Capitalised at present value of the deferred values or reversionary interests at the respective periods when the Shareholders would have been in receipt of them.
" (*e*) }

" The last item, compulsory sale, is one in respect of which it is " well established that, unless under very special circumstances, " compensation should be paid, and the amount of such compensation " is usually valued by experts at 10 per cent. upon the selling price of " the undertaking.

" In addition to the above, the purchaser would have to take a " transfer of and be liable for the authorized debentures or loan " capital expended by the Water Company, the interest upon which " has been previously debited to the revenue account in diminution of " the net profits of the undertaking.

" *The aggregate amount of the above should be the sum to be paid to " the Water Company, less the present value of any outlay which may be " proved to be necessary to put the works in a position to enable them to earn " the present and prospective income, and less also the amount of the reserve " fund, which may have become necessary to replace any parts of the works " requiring renewal.*

" In 1875 the Corporation of Birmingham purchased by " agreement the undertaking of the Birmingham Water Company " upon the following basis :—

	£	£
" Largest realized profit	47,712	
" (1) Maximum statutory dividend on " called-up capital, although not " realized, viz. :—		
" (*a*) 8 per cent. on £420,000...	33,600	
" (*b*) 7 per cent. on £252,000...	17,640	
		51,240

	£
"(2) Allowance for possible future profits on "£84,000 not called up. Present value of "deferred interest, calculated at 3 per cent. "thereon	2,376
"(3) Allowance in respect of Shareholders' "interest in arrears of dividend amounting "to £52,520, which may hereafter become "payable, if and when the Company's profits "shall become sufficient for that purpose, "present value estimated at one-half the "amount of arrears, and converted into per- "petual annuities at 4 per cent. saleable at "25 years' purchase...	875
	£54,491
"The Corporation agreed to pay on the above "footing perpetual annuities secured on the "Water Works Income, and all rates of the "town, and property of the Corporation ...	£54,491
"Estimated at the saleable value of 25 years' "purchase, or amounting on the whole to "£54,491 × 25	1,362,275
"(4) And to this was added, for winding-up "purposes, the sum of	3,022
"Making a total of	£1,365,297

"Being $\frac{1,365,297}{47,712} = 28\frac{6}{10}$ years' purchase on the largest realised "dividend of the Company.

"(5) Besides this, the Corporation took over all the mortgages "of the Company, and all its debts and liabilities."

I do not know whether you and other members of the Council have considered the large sum of money which will be required for the purchase of Surrey's share of the Lambeth and Vauxhall Companies, and the additional expenditure which will be necessary to place the water supply of these parishes in an efficient state. I

fail to discover in what manner the option of two years in the agreement made between the Councils of Surrey and London will be of any benefit to the ratepayers of the North-Eastern part of Surrey by the division and cutting up of the districts which are now supplied by these Companies.

I am,

Yours faithfully,

A. H. SMEE.

The Case of the Mill and Riparian Owners on the River Wandle.

MEMORIAL TO THE LOCAL GOVERNMENT BOARD.

The memorial to the President of the Local Government Board gives a resume of the prolonged opposition raised by the late G. P. Bidder, Q.C., Mr. Smee, and other riparian owners, against the attempted encroachments on the springs of the Wandle in 1882 by the London and South-Western Water Company, who proposed to sink a well on the Glebe lands at Carshalton, in close proximity to the head springs of the Carshalton branch of the Wandle; and in 1884 the Corporation of Croydon attempted to sink a well at Woodcote, two miles from the Wandle. Both these Bills were successfully resisted in Parliament. In 1887 the Sutton Water Company, in a Bill for raising new capital, inserted a proviso that they could not sink new wells in any land they might acquire, and in 1897-98 the Croydon Corporation endeavoured to obtain a loan from the Local Government Board in order to construct wells at Waddon within one mile of the Waddon springs, although by the Bill of 1884 they gave an undertaking to a committee of the House of Commons that they would not sink any well on land acquired by them under that Act, except at the site of their new works at Addiscombe.

THE CASE OF THE PROPRIETORS SUBMITTED TO THE PRESIDENT OF THE LOCAL GOVERNMENT BOARD.

The Riparian Proprietors and the Owners and Occupiers of Mills on the River Wandle are threatened with a very serious danger. The Corporation of Croydon, who supply water to the greater part of their Urban District, have recently bought six acres of ground at Waddon by agreement from the Ecclesiastical Commissioners, and

are applying to the Local Government Board for their sanction to borrow £32,000 to enable them to sink a well and erect pumping machinery on the site so bought. This site is situate about 1,200 yards from and above the Waddon Springs and Ponds, which form one of the main sources or feeders of the Croydon Branch of the River Wandle, and the Corporation anticipate, and rightly, that they will take the water which flows underground at or near this point, where they propose to sink their well, on its way from the South and South-East towards the Waddon Ponds, where it comes to the surface in springs yielding from one million gallons to eight million gallons a day. The machinery which the Corporation propose to erect is very powerful, and capable of pumping four million gallons per day. The dry weather flow of this branch of the Wandle, including the Croydon flow, is only two million gallons per day, and at times much less, and the Corporation, if they are allowed to erect the machinery, will be able, when the springs are low, to drain almost dry the Waddon Ponds and the Springs which supply them, and take the waters coming down from Croydon.

The effect of this will be to seriously diminish the value of the Mills, and, indeed, of all the property on the Croydon Branch. The mischief, however, will not stop here, for the water in the Wandle below the junction of the Croydon and Carshalton Branches will be greatly diminished ; in dry weather it will lose about one-fourth part or more of its volume, and when it reaches the point where the effluent from the Croydon Sewage Farm passes into it, the volume of pure water, which is now scarcely large enough to neutralise the polluting effect of this effluent, will be quite insufficient, and the purity of the water in the lower part of the Wandle will be most seriously affected, and the value of the riparian property correspondingly diminished, and the health of people living close to the River will be endangered.

It came to the knowledge of the Riparian Proprietors as early as March, 1896, that the Corporation were intending to make this attack on them, and their solicitors, Messrs. Freshfields and Williams, wrote to the Secretary of the Local Government Board on the 21st April, 1896, as follows :—

5, Bank Buildings, E.C.

21st April, 1896.

Sir,—

As representing a considerable body of Landowners and Mill owners on the River Wandle in Surrey, we are desired to approach you with reference to an Agreement, which we understand is either come to or shortly will be come to, with the Ecclesiastical Commissioners by the Corporation of Croydon, having for its object the purchase by the latter of a plot of land upon which it is proposed to bore for the purpose of obtaining a water supply. The subject of the water supply of Croydon has been well considered by Parliament, and while permission was given to the Corporation to take water in a certain direction, an absolute prohibition was given to it to take water in a place which was then considered would injuriously affect the River Wandle. The place now selected by the Corporation is not identical with that which was under the consideration of Parliament, and we understand that the Corporation, availing themselves of this, propose to do under some authority from the Local Government Board that which they were unable to do by an Act of Parliament. We are also advised that the effect of the operations of the Croydon Corporation may, and in certain circumstances must infallibly, end in the absorption of the whole of the water supply of the River Wandle, which between its source and Waddon Pond pursues a definite underground course. We are advised that an operation of this nature cannot with propriety be undertaken without the sanction of Parliament, particularly having reference to what passed when the Croydon Corporation obtained their Act in 1884. Our present object is to draw the attention of the Local Government Board to this matter in order that, if any application should be made by the Croydon Authorities for the permission of the Board to commence and prosecute such operations, an opportunity will be given to us to communicate with those whose property will be injuriously affected by these operations, to enable them to lay their case before the Local Government Board. Your Board will understand that those persons live at different points of the River Wandle, and, not being themselves ratepayers or members of the Croydon Corporation, are unable

precisely to ascertain the course of events, or to have any voice in their consideration.

We are, &c.,

FRESHFIELDS & WILLIAMS.

To the Secretary of
The Local Government Board,
Whitehall.

The Local Government Board answered this on the 4th of May, 1896, as follows :—

Local Government Board,
Whitehall, S.W.
4th May, 1896.

Gentlemen,—

I am directed by the Local Government Board to advert to your letter of the 21st ult., and to state that unless the Town Council of Croydon require to borrow money to defray the cost of the work of boring for a supply of water to which your letter refers, the Board's sanction would not be required.

At present the Board have received no application for such sanction, but in the event of an application being made, your representations shall be duly considered.

I am, Gentlemen,
Your Obedient Servant,
C. A. DALTON,
Assistant Secretary.

Messrs. Freshfields & Williams.

The Proprietors read this letter, and, not unnaturally, as an undertaking that their representations should be listened to when any application was made for the sanction of the Local Government Board to a loan.

On the 20th July, 1897, the Town Clerk of Croydon informed Messrs. Freshfields and Williams that they had applied for sanction for a loan of £32,000.

The Town Clerk was at once informed that the Proprietors would appear by Counsel and oppose the sanction of the loan, and they accordingly appeared by Counsel before the Local Government

Board Inspector on Thursday, the 29th July, 1897. Objection was at once taken by Counsel for the Corporation that the Proprietors had no *locus standi*, and could not be heard. Much to their surprise this objection was allowed by the Inspector, and the Proprietors were thus shut out from laying their case in any way before the Local Government Board, or opposing the sanction. The same Counsel, who appeared for the Proprietors, also appeared for three ratepayers, and though he was permitted to be heard on their behalf, he was expressly prohibited by the Inspector from dealing with the question of the injury that the Proprietors would sustain from the abstraction of water from the Wandle, and he was not even allowed to show that if the Corporation were permitted to pump this large quantity of water from the proposed well, they would be committing a legal wrong: first, by abstracting water which had already reached the Wandle; secondly, by intercepting water on its way to the Wandle through known and ascertained defined underground channels. It was submitted to the Inspector that a ratepayer was entitled to object to the sanction of the loan on the ground that as soon as the Corporation began to work their machinery they could and would be restrained by injunction, and the £32,000 proposed to be spent would be rendered useless; but on this point also the Inspector ruled that Counsel for ratepayers could not be heard.

These decisions of the Inspector, it is submitted, were quite contrary to the general practice of the Local Government Board. It has always been the practice of the Inspectors of the Board to hear objections from any persons substantially interested; for instance, if money is required to be borrowed for the purpose of the sewage scheme, the Inspector does not confine himself to objections from ratepayers who will be personally injured, but hears objections from persons who may be outside the district who will be injured by the proposed works. To take an illustration from a case that took place at an enquiry some few years ago at Eastleigh, in Hampshire, the Local Authority applied to the Local Government Board for sanction to borrow money for a sewage scheme. It was opposed by amongst others the Southampton Corporation, and by Mr. Montagu on the ground that if the effluent were allowed to pass into the Itchin River

the water in that river might be polluted, and the Southampton Corporation would no longer be able to use the water of that river for the purposes of their water supply, while Mr. Montagu, who was the riparian proprietor lower down, would also be seriously injured, and his salmon fishing rights depreciated. The Southampton Corporation and Mr. Montagu were both allowed to be heard, and contended that the Eastleigh people ought to take their sewage to a point in the Itchin below the intake of the Southampton Corporation, and below Mr. Montagu's property, and not only was the contention heard and evidence taken on it, but it was eventually decided in favour of the objectors that the sewage must be taken below the intake, and below Mr. Montagu's property.

If outsiders can be heard to show that the water of a river will be polluted, surely they can be equally heard to show that the water will be abstracted; and it is difficult to see how the Southampton Corporation, and much more Mr. Montagu, should have a *locus standi* to object, if it is right that the *locus standi* of the Proprietors of the Wandle should be disallowed.

This is not by any means the first attack made on the Proprietors of the Wandle, and in two cases that will be presently noticed the *locus standi* of the Proprietors to appear before a Committee of the House of Commons was expressly allowed.

In the year 1882 the Promoters of the London and South-Western Water Company proposed to sink a well some 900 yards from the Wandle, and to intercept, in the same manner as the Croydon Corporation are desiring to do, water on its way underground to the Wandle. The Proprietors of the Wandle appeared before the Court of Referees and claimed that they had a *locus standi* to oppose. Witnesses were heard—Mr. Mansergh and Mr. Baldwin Latham—and the *locus standi* was allowed. The Promoters then agreed not to sink a well in the position proposed, but nothing further came of it because the Promoters abandoned their Bill. But the more important precedent is that of the Croydon Corporation itself when it applied in the year 1834 for an Act authorising them to take water from two sites—the Woodcote site and the Addington site. The Addington site was far away from the Wandle, and would not

have affected the sources of the Wandle in any degree. The Woodcote site was about two miles away from the Wandle, but it was believed that a well, if sunk there would, as here, intercept water on its way underground to the Wandle. The Proprietors appeared before the Court of Referees, and claimed to have a *locus standi* to oppose. The claim was allowed, and they appeared before the Committee of the House of Commons to oppose the Corporation Bill so far as it sought to take water from the Woodcote site. There was a good deal of discussion before the Committee at an early stage as to the grounds upon which the Proprietors could be heard to oppose the Bill. Eventually Mr. Fowler (now Sir Henry Fowler), the Chairman of the Committee, made this statement:—

> "This question of *locus standi* having been decided, and the "Proprietors of the River Wandle having been let in, it "seems to me that the simple question is this: Is it a "question of public policy that the owners of the Mills, "and all the various interests in the River Wandle, are to "be deprived of their water supply in order to sink a well "at this point of Woodcote."

Mr. Baggallay: Quite so, sir. I do not dispute their right to be here for a moment.

Mr. Fowler: Could you not bring it to that issue whether it will or will not deprive them of their water, and then leave it for the Committee to determine, after they have heard Counsel on the matter, whether it is a right or wrong thing to do?

Mr. Ledgard: That is the object of the evidence, sir, because the whole contention of the opposition is that by these well-defined channels the water flows back to the River Wandle.

Mr. Fowler: Sir Robert Rawlinson put it on the other ground. He said: If you take all the water you can from Woodcote it would not interfere with the River Wandle.

Witnesses were examined and cross-examined on the part of the Corporation to show that the Wandle would not be affected by the sinking of the well at Woodcote. However, on the morning of the 2nd April, and before any evidence had been produced by the proprietors of the Wandle, Mr. Ledgard agreed to abandon the Woodcote

site. What took place at this stage is of great importance, and we set out the discussion at length. Page 97 of proceedings of 2nd April, 1884.

Mr. Ledgard: We have been considering this case, and various expressions of opinion which from time to time have fallen from the Committee, and one cannot, of course, help being impressed with the suggestion made by the honourable and learned member on your right with regard to not considering the question of whether or not this water flows in defined underground channels, and, of course, that might land us in a position that would be very difficult for us to meet. At the same time, it is perfectly clear and undisputed that Croydon does require some additional supply. Therefore, what I propose is this. We should be content, for the present at all events, and for some little time to come, with one of the wells instead of two. If the Committee express any opinion as to which well it should be, we should, of course, bow to their decision. There are certain advantages about Woodcote, because, in all probability, the supply from Woodcote is much larger than the supply from Addington. On the other hand, there are certain advantages about the Addington reservoir which, perhaps, are not possessed in the same degree by Woodcote. But we should be content with either well, whichever the Committee might think fit to give us. I might point out, in passing, that the Addington well is not opposed by anybody. I have other evidence which I could call upon that point if it was thought neccessary.

The Committee deliberated.

The Chairman: Are we to understand that if we adopt your view Mr. Bidder and his petition will retire?

Mr. Ledgard: I presume that if the Woodcote well is disposed of they will have no *locus standi* against the other well.

Mr. Bazalgette: No, sir, we should not retire, having regard to this fact that there is a Clause contained in the Bill which gives them a roving power to take, I think, thirty acres of land and to sink wells.

Mr. Ledgard: Mr. Bidder disposed of that before the Court of Referees. It is not wanted for the water purposes at all; it is only

for fairs and market purposes. Mr. Bidder undertook to give me then and there an agreement that he would not raise any point about it.

Mr. Bazalgette: I should like, with your permission, to have Mr. Bidder present before I said definitely that we would retire. By my reading of the Bill, as amended, they have power to sink wells wherever they can acquire lands. That being so, it is quite clear that, in order to protect ourselves, we should have to ask for a Clause to be put in the Bill to restrict them from exercising a roving power as to this land.

At this point Mr. Bidder came into the room.

The Chairman: Counsel for the Promoters, Mr. Bidder, have stated that they are prepared to abandon, if the Committee adopt that view, their scheme for Woodcote, and confine their application to Addington only. We were asking, before you came into the room, whether, if the Committee adopted that view, your Petition would be got rid of, and you would be satisfied. With reference to that remark which Mr. Bazalgette made just now, of course, if they say "We are content with the Addington supply," we shall not give them a roving commission to take twenty or thirty acres anywhere else. It must be limited to that locality which the Committee is going to deal with.

Mr. Ledgard: The filled up Bill in Clause 147 points out that the land is only to be taken for the purposes of Part IV., which relates to the markets.

Mr. Bidder: I understand my learned friend (and no doubt he thoroughly intends to carry out what he proposes to the Committee) to definitely abandon the power to sink a well at Woodcote; and I suppose, inasmuch as Mr. Littler told us the other day that in consequence of my criticisms they had determined to limit the power to take land for market purposes, he will have no objection to make it clear in his Bill that no power of that kind is to be exercised for getting land for water purposes?

Mr. Ledgard: That is so. There is no such intention on our part, and there never was.

Mr. Bidder: All that we are anxious about is to take care that that cannot be done indirectly which is abandoned directly.

Mr. Ledgard: You may take it from me that that is our wish and intention.

Mr. Bidder: As soon as we see that our water is protected our opposition is at an end.

Mr. Ledgard: Of course, Sir, you will gather that I can produce information as to the necessity for the water from the Medical Officer and other witnesses ?

The Chairman: Oh, yes. We will clear the room.

(The Committee Room was cleared.)

After some time the Counsel and parties were again called in.

The Chairman: The Committee are prepared, Mr. Ledgard, to give you the powers that you ask for with referencee to the Addington Station, and the Addington Station alone, and of course your finance arrangements will have to be modified in order simply to cover the expenses to be incurred in that locality. We should require such a clause to be inserted as would be satisfactory to Mr. Bidder, to exclude the possibility of your sinking anywhere else under this Bill except in the immediate locality of Addington ; and we should also require a clause to be framed protecting the ratepayers of Croydon who live outside the two-mile radius and inside the Lambeth Water Compay's district from being in any way rated to meet the cost of this water arrangement.

It will be seen from this discussion that Mr. Ledgard assented to Mr. Bidder's requirement that the Corporation should definitely abandon the powers to sink a well at Woodcote, and that they should not use any of the thirty acres which they propose to take power to acquire by agreement for the purpose of water supply at all. It was clear that the majority of the Committee were of opinion that the Proprietors of the Wandle ought to be protected, because when Mr. Bidder subsequently asked for costs the only statement made by the Chairman was, "The Committee are not prepared unanimously to give costs, indicating that a majority of the Committee would have been willing to grant costs." It was considered by the Proprietors as the result of the decision of the Committee and of the abandonment of the proposed site at Woodcote, that they were protected for all future time from danger at the hands of the Croydon Corporation,

and it was with the greatest surprise that they heard that the Corporation proposed to buy land and sink a well, and obtain a water supply from a point even nearer to the sources of the Wandle than the Woodcote site, and they contend very strongly that it was a breach of the arrangement that had been come to before the Committee in 1884. They were however advised that inasmuch as the Act of Parliament only dealt with the land which by that Act the Corporation was given power to take, it did not affect their power to take land by agreement under Section 51 of the Public Health Act, and that although in good faith the Corporation were clearly bound they were probably not bound in law. They considered the question whether it would be advisable to take proceedings at once, but as there are always difficulties in a *quia timet* action they determined not to take legal proceedings before they were actually injured.

Whether however the Proprietors have legal grounds for restraining the Corporation in taking this water is not the question that we are dealing with at present. The question at present is whether it is right that a Local Authority should be allowed to sink wells and erect machinery to enable them to take water directly on its way to a river like the Wandle, and whether the interests of the Proprietors of the River Wandle, and indeed of the inhabitants in the neighbourhood of the River Wandle, ought to be sacrificed to the interests of the Local Authority, who beyond doubt can get water from other places without affecting the Wandle.

This is the question which the Committee of the House of Commons, in the year 1884, had to consider, and decided against the Corporation. There may be cases, possibly, where the necessities of the Local Authority are so urgent, and the difficulties of obtaining water elsewhere are so great, that the interests of the Local Authority should prevail, and we proceed to consider for the moment whether this is so here.

The position at present at Croydon is that the Corporation have a well called the Surrey Street Well, from which they can obtain 2,100,000 gallons per day. They have wells at Addington which have continuously yielded in dry weather over 1½ million gallons per day, and from which they are entitled to take 90 million gallons during the

course of any two months. As a fact, during the past year they have been taking less than half this, and the water they have taken has been just sufficient to supply their wants. They have, therefore, ¾ million gallons per day at present to spare, and have no urgent want. Indeed, it is plain from the questions put to Mr. Whitaker, the geologist, whose opinion was taken by the Corporation, and his report, in October, 1894, which is annexed hereto, that the Croydon Corporation have far greater aims than merely getting sufficient water to supply their present wants. They want to possess themselves of the remainder of the Borough which is supplied at present by the Lambeth Company. They want to get hold of large sources of water supply, and to be in a position to sell to some other body, whether it be a London Water Authority, or a County Water Authority, or some other Local Authority, their surplus water. It is submitted that these objects are wholly illegitimate, and that the Corporation should be strictly confined to obtaining such water as may be absolutely necessary for their own wants. It would probably be far safer for the Corporation to obtain their water from a more sparsely inhabited district south of them; and places could be pointed out where they could obtain a supply that would be free from pollution, which is certainly not the case with the water from the proposed site.

But if the Local Government Board thought it proper, the Proprietors would be willing to come to a reasonable compromise with the Corporation. There is no doubt that their Surrey Street Wells tap the sources of the Wandle and intercept water that would certainly reach the Wandle. Their Surveyor has informed the Inspector that they look to obtain three-quarters of a million gallons from the proposed well. This, added to the water they obtain from the Surrey Street well, would make something less than three million gallons per day. The Proprietors of the Wandle would be content that the Corporation should take from the Surrey Street wells and from the new well together a quantity up to three million gallons per day, provided that they undertook for the future to take no further water within certain limits which could be agreed upon. The Corporation would then be in a position to take three million gallons, either wholly from the new well or partly from this and partly from

the Surrey Street well, whichever they preferred. They would also be in a position to take one and a half million gallons from the Addington wells, making four and a half million gallons per day, or half as much again as they have been lately consuming. This ought surely to be sufficient for them.

If the Corporation are not content with this it affords the plainest evidence of what we have before suggested, that their object is not confined to obtaining a supply for the present district, but that they have some other object in view. From what is stated above it is clear therefore, that there is no necessity that the interests of the Proprietors of the Wandle should be sacrificed in any way. Further it should be considered whether, having regard to the litigation that would certainly follow if the Corporation were allowed to erect this machinery, and the pumping resulted in substantial injury to the Wandle, and to the fact that if such litigation were successful the whole of the £32,000 would be practically thrown away, this is a case where the Local Government Board ought not to assist the Local Authority in any way whatever,

What the Proprietors desire is an opportunity of laying their case fully before the Local Government Board, or some independent person. They are prepared to demonstrate that every drop of water to be pumped from the proposed new well will *pro tanto* diminish the flow of water in the River Wandle, and that there will be a substantial injury to the Proprietors of the Wandle, and will substantially diminish the purity of the river. They believe that they can show that water will be abstracted which has already reached the Wandle, and that defined and ascertained underground channels will be tapped, in either of which cases they will be entitled to an injunction. They do not, however, desire a costly litigation, and they are willing to make a compromise which they can show to be not only fair but liberal. They consider that the battle has been fought and won before a Committee of the House of Commons, and that the Local Government Board ought not to allow the Corporation to do that indirectly which the House of Commons refused to allow them to do directly. They further pray in aid the important evidence of Mr. Baldwin Latham and Mr. Smee, which was given on the Enquiry, as to the

danger when the springs are dry, that the water to be pumped from this new well will be polluted water, and the following Notice, issued by the Croydon Rural District Council on the 25th of June last, which proves abundantly that pure water cannot be spared from the River Wandle :—

"Croydon Rural District Council.

"caution.

"The public are warned by the Croydon Rural District Council "not to use the water in this stream for drinking or other "domestic purposes, and parents are strongly urged not to "allow their children to bathe, paddle, or play in the stream "owing to the possible risk of injury to health incurred "thereby.

"Purveyors of watercress or other articles of food are cautioned "against washing or cleansing such articles of food in this "stream, or in water derived therefrom, and are hereby "warned that by so doing they are liable to have such "articles of food seized and destroyed as unfit for the food of "man.

"By order,

"James Wilson,

"Clerk to the Council.

"District Council Offices, Croydon,

"*June 25th*, 1897."

COUNTY BOROUGH OF CROYDON.

Instructions to Messrs. Topley and Whitaker to advise as to further sources of Water Supply.

1.—The Council are desirous of being advised by Mr. W. Topley, F.G.S., and Mr. W. Whitaker, F.G.S., as to further sources of water supply for the Borough in the future.

2.—The Corporation at present supply water to so much of the Borough of Croydon as is within a radius of two miles from the Town Hall, and also to so much of the Borough as lies to the south of such radius. The portion of the Borough north of the radius is supplied by the Lambeth Water Company.

3.—It is not improbable that the Corporation may be able, in connection with future legislation as to the London Water Supply, to acquire the right to supply so much of the Borough as is now supplied by the Lambeth Company.

4.—The population of the Borough was estimated on the 30th September last at 109,700, and it may be taken that of the total population 84,730 inhabitants, occupying 15,910 houses, reside within the district supplied by the Corporation, and 24,970 inhabitants, occupying 4,473 houses, reside within the district supplied by the Lambeth Water Company. It may be added that the rateable value of the houses within the Corporation district of supply is £393,862, and the rateable value of the houses within the Lambeth district of supply is £158,632.

5.—Water is at present supplied from two sources. The first consists of four wells syphoned together in Sturt's Yard, to the west of Surrey Street, about 150 feet above the ordnance datum.

6.—The area occupied by the four wells is about 50 yards square, or say an area of some 2,500 yards. The first and second wells were sunk in the year 1851, the third in 1867, and the fourth well was completed in 1877. These four wells are all lined, principally with cast-iron cylinders, so as to shut out surface and subsoil water to depths as herein stated: Nos. 1, 2, and 3 wells, to a depth of 50 feet from the surface; and No. 4 well, to a depth of 62 feet 6 inches from from the surface; the subsoil being loamy gravel down to the chalk, which commences at a level of 135 feet above ordnance datum.

7.—The ordinary level of the water in the wells when at rest is about 10 feet below the surface. In wet seasons, when the springs and subsoil water are high, pumping reduces the head in the wells about 12 feet; when the springs are low pumping reduces them about 17 feet. There are deep boreholes in the chalk at each of the wells, but, no doubt, by far the largest volume of the water pumped is obtained at or about the level of from 50 to 70 feet below the surface.

8.—The water is lifted by engines to a reservoir at Park Hill, having a capacity of 900,000, and is then distributed over the lower portion of the water district.

9.—A second source of supply is at Addington, where the well is three-quarter of a mile south of Addington Village. It is 10 feet in

diameter and 205 feet deep, all in chalk. The well is not bored, but horizontal headings or tunnels, 6 feet high and 4½ feet wide, have been made, chiefly about 150 feet from the top. The total length of these is 813 yards, and they will hold, with the lower part of the well, about 502,000 gallons. Several important water-bearing fissures were cut through in the east headings, the first one yielding 600,000 gallons a day. After a wet season, when the springs are at the highest, the yield will not be less than three million gallons per diem.

10.—The pumping machinery consists of two engines, each 125 h.p. of the "Wolfe" type, five steel boilers, double-acting well and lift pumps, of the bucket and plunger pattern. Each engine is capable of lifting 77,760 gallons per hour 250 feet high, through a 21 inch pipe, into the reservoir on Addington Hills. This is 420 feet long, 124 feet broad, and 16⅔ feet deep, and holds five million gallons. It is built entirely of concrete, and supplies the higher portions of the water district.

11.—The wells in Surrey Street were established under the powers of the general Sanitary Acts. The wells at Addington were established under the powers of the Croydon Corporation Act, 1884, as to which Mr. Whitaker, it may be remembered, gave evidence in support of the case for the Corporation.

12.—The following table has been prepared by Mr. Walker, the Borough Engineer, and gives the daily pumpings from each of the two sources above-named for the last five years :—

Daily Average.

	Croydon.	Addington.
1889 ...	1,785,000 gallons. ...	606,000 gallons.
1890 ...	2,071,000 ,, ...	628,000 ,,
1891 ...	2,252,000 ,, ...	600,000 ,,
1892 ...	1,914,000 ,, ...	738,000 ,,
1893 ...	1,948,000 ,, ...	777,000 ,,

13.—The quantity of spring water gaining access to our sewers, and also finding its way into the head of the Wandle by the Bourne Culvert and the Church Road Culvert, may when the springs are lowest, be safely put at half-a-million gallons, and when at the highest one-and-a-half million gallons per day.

14.—The East Surrey Water Company have recently put down a new well and much larger pumping engines at their Kenley Water Works, and increased their pumping power, so that the quantity abstracted now is not wide of a million gallons per day. This would probably be looked upon as drawing from the same source of supply as that of the Croydon wells.

15.—The following table gives the population of Croydon at the various census periods since 1801 :—

1801	...	5,748	1851	...	20,548
1811	...	7,903	1861	...	30,663
1821	...	9,279	1871	...	56,123
1831	...	12,479	1881	...	79,615
1841	...	16,730	1891	...	102,697
Estimated by Dr. Philpot on 30th September,	...	...	1893	...	109,700

16.—Having regard to the constantly increasing population, and to the delay that necessarily must occur after new sources of supply have been decided upon before legislative authority can be obtained for them, and before they can be brought into work, and having regard also to the fact that various sources of supply are being gradually absorbed by water companies, the Council feel that they should consider where they should look for a future and new source.

17.—The pumping station at Addington, which was sanctioned by the Croydon Act of 1884, was seriously opposed by the Kent Water Company, who at the time said they were contemplating sinking wells at Wickham, not far from the Addington site. The powers clause was modified for their protection by the proviso at the end :—

> " Subject to the provisions of this Act the Corporation may " from time to time collect, take, divert, appropriate, use, and " impound into their said intended reservoir and works or some " of them, and thence distribute the waters which may be " obtainable by them from the well and pumping station by this " Act authorised to be constructed, or from any springs, streams, " brooks, or other waters which can or may be intercepted or " abstracted by means of the said intended reservoir, or by means " of any of the said intended works ; provided that the Corpora-

"tion shall not at any time raise a greater quantity of water "from the said pumping station than 90 million gallons in any "consecutive period of two months."

18.—If, however, the Corporation are so advised, and should purchase land for a further supply of water at Addington without going to Parliament for the purpose, it may be a question whether the Kent Company would now oppose them. The Kent Company carried out some borings at Wickham, but those borings apparently were not satisfactory, for all apparatus has for some time past been removed from the site, and the fence which surrounded the site has been taken down.

19.—When the Act of 1884 was promoted the Corporation also sought sanction to a site at Woodcote, where it was believed a vast quantity of water was on its way from the south, and particularly from Merstham to the springs of Beddington, Carshalton, and the sources of the Wandle. The Bill was warmly opposed as regards this site, mainly by mill and riparian owners on the River Wandle, and the Corporation dropped the clauses which would have authorised it.

20.—The Council will be glad to be advised:—

(*a*) For how long they may rely upon it that the present sources of supply will be adequate for the population assuming it to increase in the ratio which the last censuses have indicated; and for how long the purity of the supply is likely to remain unaffected by the rapid increase of building round Croydon, especially on the southern side.

(*b*) What further supply should be provided in the not improbable event of the Corporation being able, by means of any legislation with regard to the London Water Supply, to acquire the right to supply the district now supplied by the Lambeth Water Company.

(*c*) Where the Council can rely upon finding other and supplemental sources of supply, and to what extent such sources may be relied upon.

CORPORATION OF CROYDON.

REPORT AS TO THE FUTURE SOURCE OF WATER SUPPLY.

By Mr. William Whitaker, B.A., F.R.S., F.G.S., Assoc. Inst. C.E.

WATER SUPPLY.

To the MAYOR AND CORPORATION OF CROYDON.

GENTLEMEN,—

Owing to the much lamented death of my friend, Mr. Topley, the task of writing this report has fallen wholly on me. I can, however, fairly claim to write on his behalf, as we had gone over the country together, and had thoroughly talked over the subject. Although we were in accord in our conclusions, I cannot but feel how much is lost by the want of his aid in bringing those conclusions before you.

1.—The first question submitted to us in your instructions refers in the first place to the time for which the present sources of supply will be adequate, assuming that the population continues to increase at the rate at which it has increased for some time.

2.—This increase means, in round numbers, that 23,000 people will be added to the Borough population at the census of 1901, as compared with that of 1891. But this includes the population of that part of the Borough which is not supplied with water by the Corporation, the substraction of which would make the increase in question about 18,000, supposing that rate of increase is equal over the whole Borough.

3.—At the Addington Works you are empowered to take about 1½ million gallons a day, but you have not taken more than 770,000 (on the average in a year). The extra 700,000 gallons or so that you could take would be more than enough to supply the estimated excess of population to 1901 at the present rate of supply, which seems to be at the rate of 32 gallons a head.

4.—But this does not take into account the possibility of the northern part of the Borough, now supplied by the Lambeth Water Company, being transferred to you, an addition of about 25,000 people now, or say 30,000 in 1901. (See second question.)

5.—It is clear that the old Croydon Works are well placed for getting a large supply, as pumping at the rate of about two milllon gallons a day reduces the water level only 17 feet at the most. Moreover, no galleries having been driven there, but the supply being got simply by wells and borings, the yield could probably be enlarged greatly. The facts, however, that these works are in the midst of a thickly populated tract, and that population has extended and is extending widely over the chalk and lower tertiary tract south-west and east of them, makes one afraid to advise any extension; rather would one be inclined to recommend the gradual abandonment of these works, in view of the danger of their water becoming polluted

6.—The underground flow of water is more or less from the south, and in that direction houses have increased greatly in number, and they are on chalk, the formation from which the water is got, to on fairly permeable beds above it.

7.—The second part of the question as to how long the purity of the supply may remain unaffected it is really impossible to answer. One can only advise you to be prepared, so that should danger come you may be ready to grapple with it.

8.—The second question refers to the further supply that would have to be provided if you acquired the district in the Borough now supplied by the Lambeth Company. This at the present time implies an addition of about 25,000 people. The increase to the full of the pumping power at the Addington works would be within a trifle of enough for this, but you would then at once need a further supply for increased population. Though it seems unlikely that the event in question should come about for some time, and it could not come suddenly, of course, it would be wise to reckon on it coming at no very distant time.

9.—The conclusion that we came to on these two questions is, therefore, that steps should be taken to enable you to get a new supply, and it is to your third question, as to where other and supplemental sources of supply may be found, that we had chiefly to address ourselves, and it is with this subject that this report is chiefly concerned.

10.—Croydon is placed at and near the junction of the tertiary beds and the chalk. Though the basil part of the former here consists largely of sand, yet clays soon come on above, and at last in great force (London Clay). The effect of the overlying tertiary beds is to seal up, as it were, the top of the underlying chalk, and consequently to hold in the water, which flows down through the chalk from the south, more or less in the direction of the dip of the beds. There is no need here to allude to the local deflections from the general course.

11.—Many wells carried through the tertiary beds to the chalk are successful in getting water from the latter, but the general result of such work seems to show that the chalk is less water-bearing under a great thickness of tertiary beds than under a comparatively small one, or still more where it is practically bare. This, however, need not affect us at Croydon, as there is no occasion to take a site where the tertiary beds are thick, though it will be seen that we have not neglected sites within the tertiary tract.

12.—There are manifest advantages in keeping within the Borough boundary, if that can be done, thereby lessening expenses, and especially those from opposition, which is the more important in a tract where strong opposition is always evoked by schemes for water supply. We, therefore, determined to limit our enquiry to the municipal area unless it should be found better to go further afield, and we thought that favourable sites could be found within that area, though we have suggested also a site outside it.

13.—Of course, we put aside the central and thickly-populated parts of the Borough, and, indeed, tried to avoid population as much as possible. After careful consideration of maps, &c., and from our knowledge of the district, we selected two neighbourhoods for examination, one of them partly outside the Borough boundary, and we afterwards took a third. To these, which may be described as near the eastern, western, and southern ends of the Borough (and in the last case still further south), I will now direct your attention.

1.—The Purley Site.

14.—We came to the conclusion that the southern end of the Borough would give a very favourable site for getting a large supply

of water. This would be at a low level, near the bottom of the valley (on its north-western side), between Foxley Hatch and Purley, and would command the underground water-flow of a large tract of chalk country. Work here would not need to be at any great depth. It would consist of a shaft and gallery in the chalk, the gallery preferably from about N.E. to S.W., the direction most likely to cut fissures, though experience gained during the work may lead to trial in some other direction.

15.—We were also led to favour this site with a view to the possibility of future extension of the supply by getting water from the lower greensand. It has been proved that at Streatham, about six miles to the north, this formation is absent, the gault there resting directly on lower jurassic rocks; but the outcrop of the lower greensand is about the same distance to the south, where the formation is in force. Though it is impossible to say where the underground thinning of the lower greensand, northward from the outcrop, reaches totality, it might be well worth while to bore here to the base of the gault, in doing which some additional supply might be got from lower beds of chalk.

16.—At what depth the gault would be passed through cannot be estimated with certainty, as one cannot say how much of the upper part of the chalk is absent here, or what may be the thickness of the gault. At Caterham this thickness is about 340 feet (the greatest known) and at Streatham 188, the mean, therefore, would be about 260. I am inclined to say that the base of the gault would be reached at the depth of not more than 800 feet, and possibly at a good deal less; but that may be thought too much for a purely experimental work.

2.—The Stagbury Site.

17.—This is outside the Borough boundary, in the valley, about 2½ miles south-west of the Purley site, and south of Woodmansterne. It would also command a large underground flow of chalk water, from a different tract (mostly at all events) to that which supplies Purley, and it would be more favourable than the Purley site for reaching the lower greensand, the outcrop of which is only four miles to the south. There would be less chalk to go through here, though perhaps more gault.

18.—A scheme for taking the Stagbury site, however, would probably meet with the same opposition as was started against the Woodcote site of 1884, and which led to the abandonment of that site. This is as regards water from the chalk, but that opposition would not hold against a supply from the lower greensand.

19.—It may be well to note that the question of lower greensand water was alluded to in some detail in our report of 22nd October, 1886, to which reference may be made.

3.—Stroud Green Site.

20.—We now come to a site of a different character, within the tertiary tract, a little eastward of Stroud Green and southward of the old racecourse, in the low ground just below the boundary of the London clay, and close to your circle of two miles radius.

21.—A shaft here would pass through the lower London tertiaries, which are largely of a pebbly and sandy character in that part (so that some water might be got from them). As in the other cases the supply would have to be got from the chalk by means of galleries, and we came to the conclusion that a large supply could be got, the thickness of the tertiary beds not being very great (say about 100 feet).

22.—This site would be fairly handy for the reservoir on the Addington Hills.

23.—Here there would be no question of boring to the lower greensand, to reach the top of which it would be needful to go down about 1,000 feet. Moreover, the site is so far northward that the formation is unlikely to be present in any great thickness, and it may possibly be absent.

24.—Of course care would have to be taken in getting water from the permeable tertiary beds, that no surface contamination is admitted.

25.—Whilst at the Purley and Stagbury sites there would be no need to spend money on trial-borings, in this case it might be well to bore down to the chalk in order to find out the nature and the thickness of the tertiary beds.

4.—The Waddon Site.

26.—Close to the western boundary of the Borough, near Coldharbour, just south of the L. B. & S. C. Railway, would

undoubtedly be a good site for getting water from the chalk, with probably the least amount of work, for springs break out just to the north.

27.—Whether the almost inevitable Wandle opposition would be able to hinder such a scheme is beyond my power to say.

28.—In this case, as in the last, one would hardly entertain the question of boring to the lower greensand, for nearly the whole thickness of the chalk would have to be pierced, and a total depth of about 900 would be needed to reach the base of the gault.

29.—Reviewing the whole question, the extension of the supply from your Addington Works ought to be considered. Should this call for additional work there, it would be well to come to an understanding with the Kent Water Company on the subject; and to find out whether that company has given up the idea of getting water in that neighbourhood. Any conflict between water authorities is a thing to be avoided.

30.—As regards the newly suggested sites, it might be safest to take the Purley site in the first place, partly because it seems to offer less chance of opposition than the Waddon and Stagbury sites. Apart, however, from the question of opposition, the Waddon site has much in its favour, especially in the undoubted presence of water in quantity.

31.—Having regard to the rapid increase of the population of the Borough, we came to the conclusion, however, that you should be prepared to adopt also a second site, so as to be ready for that future extension that seems inevitable, especially in view of the possible gradual abandonment of the old Croydon Works. Here the Stroud Green site seems to come in, and it avoids opposition. The first work, of course, should be carried out before the other is begun, the need for the latter depending much on the amount of success of the former. The Lambeth Water Company, or any public authority that may absorb it, cannot refuse to supply the part of the Borough now supplied by that company until such time as you are ready to take it over. There would be an advantage in having works so placed as to command the utmost possible lateral extension (from W. to E.) of the chalk. The Waddon site is at your western limit, and the Stroud Green site near your eastern one.

32.—It may be well here to draw attention to a matter of general interest as regards water-supply from the chalk in your neighbourhood. For many years there has been an increase in establishments of a large kind (asylums, schools, &c.) over the chalk tract of Surrey. These institutions have to dispose of their sewage, and this is done by irrigation, to a great extent over more or less bare chalk, though partly over the loam and clay that occurs as an irregular capping on the higher grounds of the chalk tract. In some cases, too, cemeteries have had to be set up.

33.—A careful watch should be kept on this sort of work, and everything should be done to prevent its serious increase, and to insure that refuse matter is disposed of in such a way as to lead to the least risk of damaging the water in the chalk. I am glad that Mr. Topley lately helped (and to his own great satisfaction) in preventing the establishment of a sewage farm on a site that gave an opening to this risk of damaging the water in the chalk southward of Croydon.

34.—In this matter you might well consult and act with the Surrey County Council, and I should advise you to enter into communication with that kindred body in order that the disposal of sewage, &c., within its jurisdiction, over the chalk tract southward of Croydon, may be carried out in the best possible way, so as to avoid risk of water pollution.

35.—Another important general question is the prevention of waste. I cannot but think that, as time goes on, and as increase of population, as well as increase in sanitary demands, leads to further calls for water supply, the question of waste-prevention, will come very much to the front, and I believe that much can be done in this line without stinting any needful use of water.

36.—The Borough boundary having been often alluded to in this report, it may not be out of place to hint that the said boundary is not altogether perfect, but seems to be susceptible of improvement, so that some day the question of extension may crop up.

37.—For instance, a dispassionate outside observer can see no good reason why a tract of land, bare of buildings, on one side of a road, should be included in the borough, whilst the houses on the other side (at Purley) should be outside it. Awkward arrangements of

this sort may interfere somewhat with the establishment of pumping stations, as it is convenient for an authority to have control over the surrounding surface for some distance from their works.

Trusting that all the questions submitted to us have been fairly and fully answered.

I am, gentlemen,

Your obedient servant,

WILLIAM WHITAKER.

33, East Park Terrace, Southampton,

29th October, 1894.

THE WANDLE PROTECTION BILL.

In consequence of the frequent endeavours of the Croydon Corporation and other water companies to abstract water from the Wandle by sinking wells within its water shed, acting with the other mill and riparian owners on the river, we determined in 1899 to promote a Bill for the protection of the Wandle. The following is the text of the Bill:—

Preamble. WHEREAS the maintenance and improvement of the flow and purity of the waters of the River Wandle in the County of Surrey are matters of local and public importance.

And whereas the Wandle derives its main supply of water from the chalk strata within the area defined in the Schedule to this Act.

And whereas several water companies or authorities already possess wells and pumping stations within that area whereby large quantities of water are abstracted for sale and they also own or have power to acquire further lands within that area subject in some cases to Parliamentary restrictions as to sinking fresh wells but in other cases without restrictions.

And whereas the lower portion of the River Wandle is largely polluted by sewage and otherwise and any further depletion of the river would not only injure property but would tend to increase the pollution so as to cause a nuisance endangering the health of residents in the neighbourhood.

And whereas in these circumstances it has become expedient to make provisions for the protection of the River Wandle and of its sources of supply.

And whereas the Council of the County of Surrey (in this Act called the Surrey County Council) are willing to undertake the execution of this Act.

And whereas the objects aforesaid cannot be attained without the authority of Parliament.

May it therefore please your Majesty

That it may be enacted and be it enacted by the Queen's Most Excellent Majesty by and with the advice and consent of the Lords

spiritual and temporal and Commons in this present Parliament assembled and by the authority of the same as follows :

Short Title.

1. This Act may be cited as the Wandle Protection Act, 1899.

Execution of Act.

2. This Act shall be carried into effect by the Surrey County Council.

Restrictions on taking Water from the Wandle.

3. From and after the passing of this Act it shall not be lawful (notwithstanding anything contained in any existing Act of Parliament) for any waterworks company or for any sanitary or local authority or for any landowner or other person to sink any new wells or to drive new adits or to establish new pumping stations or to extend or enlarge existing adits except on the site of existing pumping stations so as to collect intercept divert or appropriate for purposes of sale any waters lying in or under the area defined in the Schedule to this Act.

Any company authority or person selling any water obtained in contravention of this section shall be liable for every such offence to a penalty not exceeding One hundred pounds and to a further penalty not exceeding Fifty pounds for every day on which the offence is continned after conviction.

Nothing in this section shall affect any right of collecting intercepting diverting or appropriating water by means of any existing well adit pumping station or other work so long as the same is not extended or enlarged and nothing in this section shall prevent any landowner or other person from exercising any right which he may from time to time possess of utilising any waters in or under his lands for estate purposes or for any other lawful purpose except that of sale.

In and for the purposes of this Act the word " existing " means existing immediately before the passing of this Act.

Powers of Surrey County Council for prevention of Pollutions,&c. of River Wandle.

4. The Surrey County Council may for the purpose of maintaining the purity and improving and freeing or keeping free from obstruction the flow of the River Wandle abate or remove or cause to be abated or removed all impediments and obstructions and all nuisances and abuses whatsoever in the River Wandle or on the banks or shores thereof and may without the consent of any Government Department institute or support any proceedings which

any aggrieved person body of persons or authority would at common law or by statute be entitled to institute in respect of any of the matters aforesaid or otherwise for the protection of the due flow and the purity of the River Wandle.

Recovery and application of penalties.

5.—(1) Offences may be prosecuted and penalties and costs may be recovered under this Act in a summary manner before a Court of summary jurisdiction by the Surrey County Council or by the Clerk or other officer of the Council authorised in that behalf.

(2) All penalties recovered by the Council under this Act shall be carried to the credit of the County Fund.

Powers of Court under Act.

6.—(1) A Court of summary jurisdiction before which any company authority or person is summoned for selling water in contravention of this Act may by order require any new well or adit or pumping station to be closed.

(2) A Court of summary jurisdiction before which any company authority or person is summoned under this Act for any act or default causing or contributing to or alleged to cause or contribute to the pollution or obstruction of the River Wandle may (in lieu of or in addition to any penalty) by order require such company authority or person to abstain from the commission of such offence and where such offence consists in default to perform a duty may require them or him to perform such duty in manner in the said order specified. The Court may insert in any order such conditions as to time or mode of action as it may think just and may suspend or rescind any order on such undertaking being given or condition being performed as it may think just and generally may give such directions for carrying into effect any order as to the Court seems meet.

(3) Any company authority or person making default in complying with any requirement of an order of the Court under this section shall be liable to a penalty not exceeding Fifty pounds a day for every day during which the default continues.

Appeal to Quarter Sessions.

7.—If either party in any proceedings feels aggrieved by the decision of a Court of summary jurisdiction under this Act such party may appeal to the next practicable Court of Quarter Sessions holden in and for the County of Surrey.

8.—All expenses incurred by the Surrey County Council in carrying into effect the provisions of this Act shall be deemed to be general expenses and shall be defrayed out of the County Fund. Expenses of execution of Act.

THE SCHEDULE.

Defined Area for Purposes of Act.

The defined area is an area bounded by an imaginary line drawn from Mitcham Parish Church to Norbury House thence to Croydon Old Church thence to Warlingham Church thence to Kingswood Church thence to Sutton Parish Church and thence to Mitcham Church.

The Bill was withdrawn in consequence of the opposition by the local authorities, who believed that it would be prejudicial to their rights. It served however a useful purpose in calling public attention to the injustice mill and riparian owners suffered from the decision of Chasemore *v.* Richards, by which any water company or local authority can by acquiring land in a suitable position sink wells and sell the water thus obtained for profit. By this means a river can be denuded of its water by intercepting the flow of the subterranean springs without payment of compensation to the mills on its bank for the loss of water power.

The Association of County Councils have taken the question up, and they have under consideration a draft scheme which provides *inter alia* for the constitution of a Water Authority to prevent the obstruction and pollution of rivers (also clause i., ii., iii., iv.).

(i.) Prohibition of the appropriation of water within the area of a Water Authority, for purposes of sale outside such area, without the authority of Parliament ;

(ii.) Obligation to keep records of effects of pumping, as recommended in Lord Balfour's Report ;

(iii.) Obligation of companies or authorities taking water for sale from the area of a Water Authority to afford a supply in bulk at a reasonable price to local authorities within the area demanding such a supply ;

(iv.) Power of Water Authority, on the complaint of a local authority, that wells or springs on which their population depends are being depleted by pumping for colliery operations, to require the shafts to be cased, or other precautions to be taken.

The Relation between Water Supply and Enteric Fever.

The Grange,
Carshalton,
February 17th, 1897.

Sir,—During the last two years it has been part of my official duty to investigate the variation and increase throughout Europe for the past half century, at certain periods of life, of the rate of mortality among adult males. Incidentally, I was led to examine into the relation between water supplies and enteric fever. As Parliament will have before them, in the coming session, many projects for water supply to large communities, I venture to ask that you will grant me space in your columns so that I may briefly place before your readers the rate of mortality in 1896 from fever, obtained from various official Government statistics. For comparison, and to avoid decimals, I have computed the mortality from fever, per million living, for a few typical towns, whose water supplies are drawn from widely different sources.

Rivers and Chalk.

London	137	Paris	110

Chalk.

Lemberg	288	Portsmouth	153
Rouen (and wells)	282*	Brighton	118
Hull	280	Rheims	131
Norwich	193	Lille	70
Epsom	190†		

Upland and Moorland.

Belfast	560	Birmingham (and wells in red sandstone)	214
Dublin	453	Leeds	213
Liverpool	322	Leicester	202
Sheffield	298	Brussels (and wells)	190
Manchester	229		
Glasgow	223		

Sand and Sand Lakes.

Copenhagen	74	Amsterdam	28
Berlin	65	Ghent	91
The Hague	38		

Limestone Water.

Linz	277	Gratz	101
Prague (and River Moldene)	214	Pilsen	91
Liége	117		

Snow Water Lakes.		*Mountain Water.*	
Zurich	104	Nuremberg	42
Lausanne	82	Vienna	40
Geneva	51	Munich	32

Filtered River Waters.

Magdebourg	84	Dresden	42
Hamburg	58	Frankfurt	42
Cologne	49	Altona	41

Other Sources.

Malines (shallow surface wells)	993
Antwerp (river water, treated by iron filtration, and shallow wells) ..	154
Charlottenburg (ground water freed from its ferruginous matter by exposure to air)	87
Bristol (red sandstone)..	79
Dorking (greensand)	70†

* Three-quarters of a year. † Mean of last ten years.

Unfortunately, I have been limited in my selection of English towns, as accurate information is at present unattainable, owing to the fact that the Registrar-General's mortality returns for the whole of England and Wales for 1896 will not be published until 1898.

It will be observed that towns drawing their water supply from sands, melted snow, and rivers, have a lower rate of mortality from fever than those drawing their supply from either chalk, peat, or moorland gathering ground.

Dr. Seaton, the County Medical Officer for Surrey, has shown in his report on water supplies that the mean death-rate from enteric fever for the last decade for Epsom and Sutton, which obtain their water exclusively from the chalk was at the rate of 190 per million living ; and that this rate was an increase over the mean death-rate of the previous decade. The mortality from fever at Reigate (another chalk supply) was 160. On the other hand, Dorking, which formerly derived its water from the chalk, but now obtains it from the greensand, had a mean death-rate of 70 per million, and shows a material diminution in the death-rate from this cause. In Chertsey, which derives its supply principally from the Thames, the mean death-rate from typhoid was 90 per million during the same period.

The chalk in the neighbourhood of our large towns is being progressively contaminated by the establishment on its surface of sewage farms, cemeteries, and even by the drainage from isolation hospitals. The rainfall percolating through a soil thus polluted must pass in a contaminated condition through the joint planes and fissures down to the subterranean streams—the reservoirs of this water-

bearing stratum. Surely the time has arrived for legislation for protection against further injury to this important source of supply.

A glance at the foregoing table suggests the probable existence of a law which further investigations will either confirm or refute.

In conclusion, I trust that I have made out a *prima facie* case for an exhaustive Government inquiry as to the cause of the susceptibility to, and immunity from, fever among populations deriving their water supply from various sources. Moreover, it is at least open to discussion whether municipal bodies who are empowered to levy rates for sanitary administration are suitable authorities to act as amateur managers of trading monopolies.

A. H. SMEE, F.S.S.

The Death-Rate from Typhoid Fever

Per million living for the decennial period 1881—90, in relation to the geological formation of the Home Counties, according to the Registration Districts.

A. H. SMEE.

July, 1898.

Rate per million.

SURREY.

200 Richmond.—Gravel prevalent. The London clay appears usually where the ground leaves the levels. *Water supply—Deep well and Thames.*

180 Farnham.—Bagshot sands N., Lower greensands S., separated by narrow exposure of the chalk. London clay in parts E. Patches of gravel everywhere, and peaty moss in places N. Alluvium of the Wey and tributaries. *Water supply—Greensand.*

140 Godstone.—Lower greensand. High chalk ranges in N. of district, with patches of clay and gravel. Wealden clay S. *Water supply—Softened chalk water, East Surrey Co.*

110 Chertsey.—Bagshot sands. Broad stretches of gravel and sand of different kinds, covered in many places with peat. Alluvium of the river Wey: Pirford to Weybridge, Wisley and parts of Chertsey and Weybridge built on alluvium.

110 Guildford.—Various. N. part of district on Bagshot sand (with peaty patches), separated by exposure of the chalk (E. and W.) from the lower greensand. Alluvial bed of the Wey built on at Godalming, at Guildford, and at Woking; patches of gravel adjacent.

110 Croydon.—Chalk and gravel. Chalk prevalent E. and S. In the N. extensive gravel levels, bounded E. and W. by the London clay. Alluvium at Merton and Mitcham; thickly bult on in places. *Water supply—Thames, Kent, Croydon, Sutton Co., chalk water.*

90 Dorking.—Very varied. Wealden clay and sand in the S. Chalk in the N. (Mickleham and Effingham). Lower greensand exposed at Dorking, Abinger, and Wotton. Alluvium and gravel along the course of the Mole. *Water supply—Greensand.*

80 Hambledon.—Lower greensand. Wealden clay and sand in the S. Small stretches of Alluvium, upper waters of the Wey.

80 Kingston.—Gravel and clay. Gravel levels N. near the Thames. Alluvium (river Mole) at Esher and East

Rate per million.

Molesey, built on in places. As the ground rises S. it becomes overlaid with London clay. Bagshot sands on Esher Common and at Wimbledon. *Water supply—Thames.*

70 Epsom.—Chalk and London clay, almost equally divided (N.E. to S.W.) Sands and clay overlay the chalk in parts, as at Banstead. Alluvium and gravel of the Mole valley: Cobham to Leatherhead. *Water supply—Chalk.*

30 Reigate.—Lower greensand. Chalk in N. of district, with wide patches of sand and clays. Wealden clays in S. with patches of gravel. Reigate and Redhill various sandy clays (lower greensand). *Water supply—East Surrey, chalk water—greensand.*

KENT.

330 Faversham.—Chalk, extensively overlaid with clay. Patches of gravel and brickearth in the N. Wide alluvium of the Swale (very thinly inhabited).

320 Milton.—Very varied. Chalk overlaid with different clays. London clay in the N. Gravel and brickearth in the lower grounds. Alluvial marshes bordering the Swale.

280 Canterbury.—Gravel and brickearth, intersected by alluvial basin of the Stour. Part of Canterbury town built on alluvium. *Water supply—Softened chalk.*

260 Eastry.—Chalk. Overlaid N. with gravels and clays. Much marsh land. Sandwich and Deal partly built on alluvium.

250 Thanet.—Chalk, with clayey and gravelley patches. Alluvium in wide stretches W. and S. Buildings at Minster on alluvium. *Water supply—Deep wells in chalk, Margate and Ramsgate.*

200 Malling.—Lower greensand mainly. Gravel and alluvium in Aylesford and Snodland (partly built on). Chalk belt in the N. Wrotham and Stansted. Wealden clay at Shipborne and E. and W. Peckham.

180 Sheppey.—London clay in the N., with patches of gravel and sand. Larger part of the island alluvium.

Rate per million.

170 Blean.—London clay chiefly. Various sands in the S. Gravel and alluvium of the Stour, near Canterbury and Sturry.

170 Medway.—Chalk. Strips of gravel and alluvium by the riverside. *Water supply—Chalk water.*

160 Strood (or North Aylesford).—Chalk, overlaid in patches with gravel and pebbly clay. Alluvium by the Medway built on at Strood).

150 Dartford.—Properly a chalk district, but in N.W. several square miles of clay and pebble. Gravel in strips and patches everywhere. Much alluvium along the Thames and the beds of the Cray and Darent. Large population on the alluvium at Dartford, Crayford, Bexley, Stone, and South Darent. *Water supply—Kent Co., chalk.*

140 Dover.—Chalk, overlaid in parts with strips of clay. Lower part of Dover and suburbs built on gravel.

130 Cranbrook.—Hastings sand, with some clayey parts. Wealden clay N.E.

130 Bridge.—Chalk. Clay and sand in patches. Strip of alluvium and gravel N.E. from Bridge village.

120 Maidstone.—Lower greensand N. Wealden clay S., with patches of gravel, and strips of alluvium of the river Beult. Maidstone mostly built on gravel. The Medway, from Barming to Maidstone, exhibits no alluvium—perhaps flows over an impenetrable clayey soil. *Water supply—Greensand and chalk.*

110 Gravesend.—Chalk. Sand and pebbly clay on hill top. Strip of alluvium at Milton (partly built on).

110 Hoo.—London clay, with some gravel. Many miles of alluvial marsh land. Patch of chalk exposed in Cliffe parish. Gravel and brickearth in places.

110 Eltham.—Chalk, overlaid with gravels and clay. Lower greensand in the S. Hythe built on alluvium and shingle. Some of the highest ground in E. Kent at Paddlesworth.

Rate per million.

110 Romney Marsh.—Alluvium and shingle. Lydd, New Romney, and the new place called Littleton-on-Sea are built on shingle and sand.

100 Tunbridge.—Hastings sand, with patches of clay. Varied clay and gravel in the N. The whole intersected by alluvial bed of the upper Medway. Part of Tunbridge town built on alluvium.

100 Hollingbourne.—Chalk heights in the N., with clay in patches. Separated from the lower greensand by a band of gault in the valley. Weald clay in S. part of the district.

100 West Ashford.—Lower greensand. Chalk heights in the N. Wealden clay S.

90 East Ashford.—Very varied. Chalk in the N., with clayey patches on the heights. Lower greensand S. Alluvium by the upper waters of the Stour. Sandy vale of several miles between Ashford and Wye.

80 Bromley.—Gravel and sand beds in the N., with wide patches of London clay. Chalk heights S., overlaid with clay and brickearth. Alluvium of river Cray (built on in parts) with gravel adjacent. *Water supply—Kent chalk.*

70 Sevenoaks.—Lower greensand. Sandy clays, with wide stretches of sandy upland. Wealden clay in parts. Chalk belt in the N. (Kemsing, Shoreham, and Orford). Gravel and alluvium along the Darent and the upper waters of the Medway.

50 Tenterden.—Wealden clays and sands, intersected in all directions by alluvium of the Rother and its tributaries. Very marshy in parts.

ESSEX.

330 Rochford.—Clay and brickearth; patches of gravel everywhere. At Rayleigh and Thundersley exhibition of Bagshot sands; many miles of brick earth and clay with covering of alluvium. *Water supply—Deep wells at Southend and Rochford chalk.*

Rate per million.

220 Orsett.—Very variable; generally low-lying; mostly gravel and sand; London clay at Orsett, gravel and chalk near Grays and Stifford; fen at Bulphen; isolated chalk and sand at Langdon Hills. Extensive alluvial levels along the Thames and Mardyke bourne. The marshes much built on. *Water supply—Partly by South Essex, chalk.*

210 West Ham.—Gravel prevalent, except where the ground rises with London clay (Woodford and Walthamstow). Alluvium of the Lea and Roding extensively built on. *Water supply—Lea and deep wells in chalk.*

190 Romford.—Gravel extensively, until the higher grounds are reached, then London clay with patches of gravel. Stretches of alluvial land near the Thames. *Water supply—South Essex, chalk.*

190 Colchester.—Gravel and sand, interspersed with London clay in the N. Many dwellings on the alluvium of the river Colne. *Water supply—Deep well in chalk.*

160 Billericay.—Clay generally, with pebbly and sandy heights (? Bagshot sands). Many miles of alluvium adjacent to the river Thames. *Water supply—Partly South Essex, chalk.*

150 Maldon.—Clay prevalent; gravelly in parts adjacent to the marshes. Vast stretches of alluvium by the Chelmer and the Blackwater and the estuary; parts of Maldon and Heybridge built on the alluvium. *Water supply—Deep well in chalk at Maldon.*

140 Epping.—Clay, with patches of gravel and sand on some of the heights. Alluvial meadows of the Lea and Roding, built on in a few places. *Water supply—Herts and Essex, chalk.*

140 Tendring.—Sand and loam, with London clay in parts; numerous watercourses on clayey bottoms. The district nearly surrounded by a belt of alluvium; many creeks uncovered at low tide. *Water supply—Deep wells in chalk, Harwich, Clacton, and Walton.*

Rate per million.

120 Saffron Walden.—Chalk mostly, on the junction with the great clay table-land of Essex. The district lies generally high; Saffron Walden town occupies a sort of hollow on the top of the chalk. Radwinter and the E. are almost entirely on boulder clay; gravel in the river valleys.

100 Chelmsford.—Clay, with patches of sand and pebble. The river Chelmer and its numerous tributaries have mostly gravel and loamy beds. But Chelmsford town is generally built on alluvial soil; brickearth in plenty. *Water supply--Deep well in chalk.*

90 Braintree.—Clay and gravel, the latter especially adjacent to the streams.

80 Dunmow.—Boulder clay prevalent; gravel and sand in the vale of the Chelmer and along its tributaries.

80 Ongar.—Clay prevalent, with sandy and gravelly patches on the heights. Alluvium of the river Roding and tributaries.

80 Halstead.—Clay, except in the river valleys, which are gravelly. Halstead and the larger villages are mostly on gravel.

70 Lexden.—Clay generally, with patches of gravel and sand. Alluvium along the Stour and the Colne, and by the tidal creeks towards Mersea Island.

Witham.—Clay, except in the river depressions, where it is mostly gravel. Alluvial parts along the Blackwater.

MIDDLESEX.

320 Staines.—Gravel of the Thames valley. Strip of alluvium of the River Colne, perhaps one mile by four. *Water supply—Shallow wells in gravel.*

190 Edmonton.—Clay and gravel about equally distributed; abundance of brickearth in places. Long strip of alluvium in Enfield and Waltham Abbey parishes; many dwellings on the marsh land adjacent to the River Lea. *Water supply—Deep well in chalk at Tottenham.*

140 Hendon.—London clay, except patch of gravel and pebbles, N. (at Stanmore, 500 feet); patches of sand near Hendon

Rate per million.

and Kingsbury, upper feeders of the Brent in Edgware, Hendon and Kingsbury.

130 Uxbridge.—Very varied; London clay at Ickenham, Ruislip, and Northolt; gravel and brickearth nearer the Colne valley, as at Uxbridge, Hillingdon, Hayes, West Drayton, &c. Alluvium on W. boundary of district; gravel and sand and patches of chalk at Harefield, N.

130 Brentford.—Gravel and brick earth of the Thames valley. London clay in the N. The River Brent appears to have a gravel bed almost wholly.

60 Barnet.—Clay; mostly very elevated, with a few surface ditches and water-courses; patches of gravel near Finchley and Fryern Barnet. *Water supply—deep well in chalk.*

HERTS.

200 St. Albans.—Chalk in the N. St. Albans town and vicinity varied; upper part clayey. Gravel, sand, chalk, and alluvial meadows in lower parts.

150 Hemel Hempstead.—Chalk, with clays and brickearth on eminences away from the river. Chalk near the river slopes, gravel and alluvium in the basin.

120 Bishop Stortfort.—Clay heights, with exposure of chalk near the streams. The Stort valley is on gravel and alluvium.

110 Ware.—Very various. Clay on the higher grounds, with patches of gravel. Chalk exposed near the streams (many streams N. to S.) Alluvium alongside the Lee and the Stort (built on at Ware and Stanstead).

110 Hertford.—Chalk, except in the S., where it is overlaid with clays and gravels. Several small streams besides the Lea, bordered with alluvium.

110 Watford.—Varied. All this district watered by the Colne and its tributaries. Gravel on the uplands. Chalk exposed near the rivers. Strips of alluvium, largely built on at Watford and Rickmansworth. Clayey elevation at Bushey.

Rate per million.

100 Hitchin.—Wholly chalk, except tiny patches of alluvium.

70 Hatfield.—Chalk in the N. Extremely varied S. of the river Lea; patches of gravel and overlaying clay.

60 Berkhampstead.—Chalk. Gravel in the bottom at and below the town of Berkhampstead.

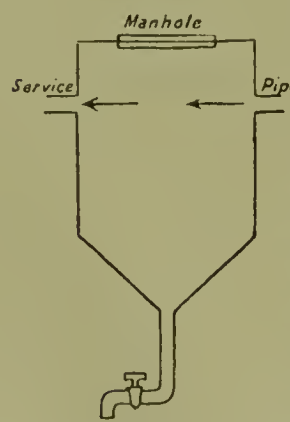
60 Royston.—Chalk heights, with patches of gravel. Boulder clay in parts, with exposure of chalk and gravel in the river valleys.

THE VALUE OF HOUSE CISTERNS.

The Grange, Carshalton,

August 30th, 1898.

Sir,—Dr. C. Hallen and other Medical Officers of Health have written that the reason why there are no cisterns at the East-end is because the local Sanitary Authorities have condemned them, and have ordered their removal, so that a direct connection with the main might be made, because they hold that cisterns are insanitary for drinking and cooking purposes. They have evidently never seen, or have ignored, the report of Colonel Ducat and Dr. Barry, Inspectors of the Local Government Board, on the East London Water Supply, which was made to the President, the Right Hon. H. Chaplin, on November 11th, 1895. The following extracts from this report may at the present time be of public interest:—"Incidentally we would refer to the advantage to the consumer of having a small storage of water in every house. It was shown that, throughout this scarcity, persons occupying houses provided with cisterns suffered no inconvenience. No doubt ill-designed and badly-placed house cisterns are open to objection from a health point of view; and nothing could be further from our intention than to advocate any return to the old defective cisterns, with their moveable wooden covers. But we do advocate the provision of *properly-designed cisterns*. By a properly-designed cistern we mean a cistern which shall be so constructed as to exclude alike the possibility of the entrance of dirt from the atmosphere, and the accumulation of any deposit from the water itself, whilst at the same time the water in the cistern is under the same pressure as the water in the main itself—in other words, the cistern that would satisfy us is merely a local enlargement of the water-main. Such a cistern is, in our opinion, subject to none of the objections commonly urged against the use of cisterns. Under the best arrangements, there must be times when short periods of interruption of a constant service will occur; and at such the want of water for domestic purposes, for flushing water-closets, sealing water-traps,



&c., is calculated to lead to conditions injurious to health which should not be allowed to exist, and which a *proper use of really efficient cisterns would guard against.* . . . In our opinion, the inconvenience experienced by consumers was much aggravated by the want of proper means for domestic storage of water. . . . That for the protection of the consumer against unavoidable temporary intermissions of the supply, we consider that there would be distinct advantage in having properly-designed means of storage of water in houses."

I enclose a rough sketch of a form of cistern which would meet the requirements in the Inspectors' report. But surely it is not beyond the inventive powers of sanitary engineers to devise several forms of properly-constructed covered cisterns, which will not only exclude dirt, but which, by adequate packing, will prevent variations in the temperature of the water.

A. H. SMEE,

Chief Medical Adviser, Gresham Life Assurance Society, Limited.

The Mortality among the Troops in South Africa.

The following appeared in the *Surrey County Herald* on July 28th, 1900 :—

The Grange,
Carshalton,
July 18th, 1900.

Sir,—It may be of interest to your readers, as the question of the medical administration of our army in South Africa has been under review, to compare our loss in South Africa with the experience of the Germans in the Franco-Prussian War.

The Germans lost, from July, 1870, to the end of March, 1871, 17,570 killed in action, 10,707 died of wounds, 319 deaths by accident, 12,137 by disease. Our army in South Africa has lost, since October 11th to July 7th, 2,666 killed in battle, 675 have subsequently died of wounds, 68 killed by accident, and 4,620 deaths by disease. It has been stated that the number of troops exposed to risk has been 223,000, and the Germans had 887,876 men in France at the termination of the war. In round numbers, the Germans had four times the number of men in France that we had in South Africa ; consequently, for the sake of comparison, by multiplying the mortality among our troops by four, we can compare the death rate of South Africa with the German campaign in 1870.

	Germans.	British.	Germans per 1,000.	South Africa.
Killed in Action	17,570	10,664	19·8	11·9
Died of Wounds	10,707	2,700	12·1	3·1
Accidental Deaths	319	272	·4	·3
Deaths by Disease	12,137	18,480	13·7	20·7
	40,743	32,116	46·0	36·0

The mortality of the German Army was, for all causes, 46·0, and in South Africa, for the nine months ending July 7th, the mortality is 36·0 per 1,000 ; the average yearly mortality of our troops on the home stations for the ten years 1878—1887 was 6·5 per 1,000. The Germans were reported to have lost 6,965 by fevers ; our army has lost 2,942 by enteric, which would be equal to 11,768 on equal numbers exposed to risk.

On referring to the weekly returns of the Alice Hospital at Darmstadt, a base hospital used principally for medical cases (many

came from Orleans), I find that 20 per cent. of the admissions were for enteric, 7·5 typhus, rheumatic diseases 18·4, dysentery 16, pneumonia and bronchitis 21·3, other diseases 9·8, mortality on admissions 4·7. It is, therefore, evident that the deaths from fever in South Africa have been far in excess of the fever mortality among the German troops in France.

Comparing the enteric death rate per million living in the chief cities of Europe, in 1899, we find :—

St. Petersburg	852	per million.
Madrid	797	,,
Rome	387	,,
Paris	284	,,
Budapest	250	,,
Brussels	223	,,
London	170	,,
New York	145	,,
Copenhagen	126	,,
Berlin	54	,,
Vienna	41	,,

Belfast, which has the worst record of any town in Europe of which I have received mortality returns, was 869.

In the Maidstone epidemic of 1897 the deaths were at the rate of 3,966 per million ; St. Petersburg, in 1880, the rate was 3,726 ; in the Franco-German War the fever rate was 7,845, and in South Africa 13,193 ; therefore, the mortailty from enteric in South Africa has been far in excess of any previous experience.

Not only has the epidemic attacked large numbers of the troops, but the number of nurses and members of the medical staff who have taken and succumbed to the disease is unprecedented.

I am,

Your obedient servant,

A. H. SMEE.

OTHER WORKS PUBLISHED BY MR. SMEE.

Tables of Mortality 1868
Gresham Life Assurance Society.

Causes of Death 1871
Gresham Life Assurance Society.

Milk in Health and Disease . . . 1875

Suggestions as to Lines for Future Research . 1881

On the Assurance of Lives Liable to Service in Military and Naval Operations as to General Population in Continental Countries . . 1888

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As to Professional, Military, and Naval Lives . 1890

Smee and Ackland.

In the Press.

Diagrams and Tables illustrating Death Rates in England and Continental Countries, and the Influence of Occupation on Mortality and Causes of Death, with the Chart of the Weekly Deaths from Plague in Bombay since the Beginning of the Epidemic 1901